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OPTIMIZING FLEXIBILITY AND RESPONSIVENESS IN

U.S. ARMY CONTINGENCY PLAN LOGISTICAL SUPPORT

THESIS

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THESIS

Presented to the Faculty of the School of Engineering

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In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Operations Research

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Preface

Since material resources are scarce, below Army acquisition objectives, the Army now has LOGPLANS/Requirements competing against one another for War Reserve material. Activation of a particular LOGPLAN, as the Commodity Command Standard System (CCSS) is now designed, gives priority to those purpose code War Reserve items necessary to implement the LOGPLAN. As the supply system's ability to fill these prepositioned requisitions becomes more responsive to commanders/crisis situations, the more inflexible we become in redirecting our support from one LOGPLAN or area to another. The question is this: "Have we traded away our ability to be flexible, i.e., ability to re-allocate material between/among OPLANS at the last moment for responsiveness, the ability to quickly fulfill requirements and provide for rapid movement thru the resupply/transportation pipeline?" As combat arms officers, the authors were interested in providing an evaluation of this flexibility versus responsiveness problem and possible solutions using a computer simulation technique. It is hoped that the results of this study will prove useful to DARCOM planners.

We would like to acknowledge our sincere gratitude to LTC Tom Clark, our thesis advisor, and MAJ Jim Coakley, our thesis coadvisor, whose guidance, suggestions, and cooperation were invaluable. Mr. Michael Sandusky, LTC Bob Works, CPT Bob Seitz and Mr. Harvey Fry of the Directorate for Readiness at DARCOM headquarters were constant sources of inspiration throughout. The aid from several AFIT instructors and students in the field of statistics and computerization was greatly appreciated.

Finally, we would like to extend our thanks to our wives, Jenny Smith and Vicki Prueitt, and children, whose patience and understanding were so important during the long hours of research and report preparation. Special thanks to Meta Gress for her assistance in preparing the final report.

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Abstract

This thesis develops a basic methodology for modeling the effects of flexibility and responsiveness in U.S. Army contingency plan logistical support.

A model of the contingency logistical support environment was built using the SLAM computer simulation language. Four factors and their interactions were analyzed in the model. Those factors were priority system, other than CONUS supplies (OCONUS), diversion, and fencing (reserved stocks). The level of each factor was varied to determine its effect and interaction with the other factors. Both airlift and sealift were modeled.

The measure of effectiveness used was the number of pallets of critical items delivered per total time in the delivery system. The model provides a number of inputs which can be changed to determine parameter sensitivity. The model results, as expected, showed that contingency logistical support would be significantly upgraded if a revised priority system, OCONUS supply sites, and a diversion policy were used.

OPTIMIZING FLEXIBILITY and RESPONSIVENESS in

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I. Introduction

In recent years, the U.S. Army Force Modernization Program has made extensive progress in fielding the latest high technology weapons systems (Ref 15:316). The newly acquired systems include tanks, armored vehicles, cannons, missiles, and computerized command and control assets. However, because of the high costs involved with each of these systems, the procurement levels have been considerably lower than those planned (Ref 31).

The consequence of falling short in the procurement levels of many supply items is that the war reserve stockage levels are only filling 22 percent of the planned volumes (Ref 28:3). Therefore, it is imperative that these important limited resources be economically allocated among the Army units that need them the most. The logistics system must be flexible enough to insure that the highest priority request is filled before others of lower priority. Current estimates indicate that the number of contingencies that can be adequately supported is limited to a maximum of two (Ref 4:18).

At a time when increased flexibility is demanded, the emphasis has been to be more time responsive to demands. This emphasis stems from the necessity to protect U.S. global interests and support its world-wide defense commitments.

The requirement has led to the development of contingency plans for each geographical location of interest. Each contingency plan is affected by time responsiveness. The faster an effective response is made, the shorter the time the defender has to prepare himself. The recent Falkland Islands War demonstrated that because the British troops were unable to deploy rapidly, the Argentinians had time to set up their defenses.

The U.S. has developed the Rapid Deployment Joint Task Force (renamed the Central Command, CENTCOM, in January, 1983) to meet the requirement of a strategic, time-responsive combat force. This force can be deployed to any location in the world in a matter of days (Ref 17:4-5). However, to sustain this force and deployed forces in Europe or Asia, the logistics system must immediately respond to their requisitions.

To enhance the responsiveness of the supply system, prepositioned and prepackaged supplies are stored in several global locations. For example, at Diego Garcia, in the Indian Ocean, there are seventeen cargo ships loaded with "roll-on/roll-off" supplies (supplies, weapons, ammunition, fuel, water, and vehicles that are prepared for off-loading and delivery) (Ref 25:76). In Europe, prepositioned stocks include tanks, vehicles, and enough equipment to outfit entire divisions. Additionally, the supporting computerized communications and transporatation assets make the logistics system highly responsive to the demands of supported commanders in crisis situations (Ref 26:1).

As reaction time decreases, however, the system appears to lose the flexibility to answer multiple or successive crises. The ability to provide or redirect support of limited resources to the most critical area is reduced by the push to fill all requisitions as soon as possible. A scenario that typifies the potential problem begins with a crisis in Southwest Asia. The U.S. interests in the area are threatened, and CENTCOM is alerted and deployed. Within a few days, prepositioned assets are drawn, and prepackaged stocks from the U.S. are in transit to support these units. Then, a major crisis develops in Europe, as the Warsaw Pact invades Western Europe. The limited resources then have multiple claimants, the delivery pipeline must be redirected (Ref 9:56) or expanded, and delivered assets may need to be reallocated (Ref 37:52-53).

A brief historical review of Soviet tactics during World War II supports the possibility that they would use diversionary tactics if the opportunity arose. During the invasion of Poland in 1939, the Soviets waited until the Poles were completely committed to fighting the Germans, and then swept in from the east, against meager opposition. In Finland, the Soviets initially invaded across a wide frontier, and once they had spread the defenders, they attacked with a massive assault along a single axis of advance. Lastly, in one of their final acts of the war, the Soviets waited until the Japanese were totally committed, and losing, to the onrushing U.S. forces, and only then declared war on Japan. This allowed them to seize some Japanese-held territories without fear of significant combat losses (Ref 39:482-493). In addition to the possibility of Soviet action, the number of unstable Middle Eastern governments capable of initiating actions that would cause the U.S. to commit forces, if only in a preemptive role, adds to the legitimacy of this scenario (Ref 38:4).

Problem Statement

What can be done to regain flexibility in the U.S. Army logistics system to permit it to adequately support execution of multiple contingency plans? Which factors must be addressed to return flexibility, and what are the relative time response trade-offs incurred? There is also a lack of a device to analyze the problem and indicate policy options in systems design.

Objectives

The primary objective of this research is to provide a validated simulation model to investigate the comparative time gains and losses for incorporated flexibility measures. Also, the possible solutions of this problem should identify optimal transit points of diversion, and the decisions that have the greatest impact on the supply process.

Intermediate objectives are:

1. Track the visibility of specific cargos from their

stateside storage locations to theater delivery. Determine if these specified cargos can be followed, managed, and/or redirected at various points during shipment.

2. Test the flexibility of the delivery system, to determine if the means of delivery has the ability for enroute destination changes, and, once a contingency is being executed, how many delivery assets, primarily MAC aircraft, are available for inter-theater cargo transfer.

3. Determine the relative time gains and losses encountered by increasing flexibility and decreasing responsiveness.

4. Evaluate the priority levels assigned to the various contingency plans, with particular attention to supporting the main contingency at less than 100% to determine the effect on other supported contingencies.

5. Examination of the present planned usage of CONUS depots as consolidation points for contingency support, to determine if multiple points (one per contingency) or a single point is more effective.

6. Examine the factors affecting reapportionment of limited supplies to multiple priority demands.

Background

To set the overall problem in perspective, a historical description of supply apportionment is given first. The services do not have a satisfactory method by which to apportion supplies and the result is that components of Unified Commands must develop OPLANs without knowledge of supply support that can reasonably be expected from CONUS during a multitheater conflict (Ref 40).

Supply apportionment is the process of planning for the distribution of scarce supply assets among various competing claimants. In the military sense, the claimants are the various units, supply pools, and contingency stocks which are tasked to support an operational plan or theater of operations.

The early Bronze Age was the last period in which an Army could expect to wage a campaign as a self-contained unit, living off the countryside, forging its own weapons, carrying only the baggage used by the individual soldier. Since that time, warfare has grown increasingly more complex to where it has become "a mere appendage of logistics in which, as Frederick the Great observed, the masterpiece of a skilled general is to starve the enemy" (Ref 14:5).

The rise of the industrialized war machine brought with it not only increased destructive potential, but the necessity for developing ever greater sources of munitions to feed it, vehicles to carry it, fuel to power it, people to repair it, and most importantly of [illegible], the necessity for rearming it as the enemy's war machine does its works.

The paradox of the increased efficiency of the modern war machine in that no nation can afford, during peacetime, to provide for all of the pieces of the logistical tail that keep the machine functioning in war. Armies are extraordinarily fast consumers of resources. It is inevitable, then, that shortages will occur in an Army, either before it is engaged or during the course of a war. It is not surprising that "logistics" comes from the Greek logistikos--"skilled in the science of mathematical computation"--for the logistician must forecast the shortages and develop the strategy to minimize the effects of those shortages on the outcome of the war.

The current world situation represents a quantum jump in the evolution of logistical warfare. Never before have two potential belligent states, the United States and the USSR, continuously maintained such large standing armies, and never before have the technological means existed to strike decisively, swiftly, and simultaneously, anywhere in the world. Any future war is likely to be global, continuous, and exhausting, with little opportunity for mobilization. The opportunity for slow buildup of resources, secure behind vast oceans, and the luxury of fighting delaying actions, with acceptable losses, until the production base can be mobilized--which has characterized most of nineteenth and twentieth century warfare--are no longer viable. It would seem that recent historical examples of logistical planning for warfare provide little insight for current situations. Nevertheless, the consideration of America's recent wars, particularly World War II, provides valuable lessons when developing a more comprehensive method of apportionment.

World War II

Logistics Environment. The logistics environment of WWII was characterized by a lengthy buildup and development of the industrial production base prior to a major commitment of forces to combat. America began to mobilize in 1940, but was not producing at maximum capacity until late 1943. At the same time personnel were being rapidly inducted and trained. Unit activation was occurring at a furious pace. The political and military decisions to open a theater of operations in North Africa, to support buildup of invasion supplies in Britain, and to supply committed troops in the Pacific and Alaska, while at the same time supporting the training base, created severe competition for available supplies. There was an extremely fluid strategic situation which kept logistics planners continuously off-balance. Lack of consistent data, poor reporting procedures, and a conscious decision to eliminate detailed logistic reporting from theaters hampered the distribution of material. The organization for logistics support went through several changes during the early years of the war.

Army Supply Program. In coordination with the Allies, planners determined the force that would be required to accomplish the global war aims. Initially, the Army estimated an end strength requirement of 12 million personnel in uniform. The logistics requirements for a force of this size were grossly determined and were combined with the logistics support that was to be given to our allies. These gross requirements were presented to industrial mobilization planners and it was quickly apparent that U.S. industrial power could not support these levels, nor was Congress disposed to fund at these levels. The subsequent scaledown of proposed end strength to 7 million personnel was but one example of many demonstrating the limiting effect of logistics on war operations. The Army Supply Program was developed to provide fiscal and budget controls, and to set production priorities and quantities. Army planners did an excellent job of determining what should be produced. A less even performance was evident in the sequence of production and its distribution.

Requirements Estimation. Computation of requirements at the theater level was greatly complicated by inter-Allied jealousies and the inability to plan deployments and operations far enough in advance. For example, the logical basis for determining requirements was to estimate the forces to be employed in each theater, add communications zone requirements, add zone of the interior, add replacement factors for combat loss/expenditures, and add pipeline factors. However, this method was rejected because it would have favored British forces already committed at the expense of American forces training at home. Operational planners

(Operation Division (OPD) of the War Department) were reluctant to predict troop allocations or future operations in such a fluid environment. The logisticians (G-4 and Services of Supply (SOS)) therefore did their own independent strategic operation planning in order to evaluate requirements. This early lack of the required information for accurate projections meant that requirements had to be determined solely on a theater basis. Several logisticians insisted that theater requirements should not be taken into account because they were convinced that the overall mobilization of production would ensure victory. "Requirements cannot be measured or determined by theaters of operation. It is the availability of trained and equipped troops, with ample, overall reserves, which will enable us to take the initiative" (Ref 14:298). In this view, current combat operations became holding actions pending the fruition of mobilization. There were, however, efforts to apply scientific estimates to requirements. Unit equipment tables (TOE) were devised for requirements determination. Replacement factors were estimated, as were consumption factors, pipeline fill factors, and shipping loss factors. However, "the uncertainty of strategic plans in 1942 ruled out specific conditions of climate, terrain, and intensity of action" (Ref 14:300). Planners complained in 1943 that after a year and a half of war the planning factors, which were originally assumptions, were still no more than knowledgeable estimates and educated guesses (Ref 14:301). "The emphasis in the requirements estimating system on the distant and general need as opposed to the immediate and specific one, involved a method of calculation that led unavoidably to overestimates in some categories and underestimates in others. As a corollary, it virtually dictated a liberal policy in allowing for unforeseeable contingencies" (Ref 14:316).

Distribution of Scarce Material. During the first year and a half of the war, the creation of task forces or deployment of units overseas was, due to severe material shortages, accompanied by massive redistribution of equipment from other units, regardless of training impact (Ref 14:303-309). Several categories of intensively managed items were created with a list of "controlled" items being centrally managed by the War Department. The list of items included mostly end items that applied to a wide variety of units. The list rose from 400 items in early 1942 to 800 in 1943, and shrank to 130 by mid-1945. Units were separated into broad categories. Group A units were entitled to the full authorized allowance, Group B units would be issued full authorized allowances progressively to bring them up to 20, 50, and 100 percent. A third group, Group C, was later created from Group B as a pool of assets from which equipment could be drawn to rapidly fill the highest priority units--in effect, cutting these Group C units (e.g., Western Defense Command) into skeleton forces. Within each group there were subcategories. If equipment had been issued by strict priority, initially there would have been no equipment for units other than the upper brackets of Group A, so there evolved several ad hoc considerations. The general priorities were:

1. Troops immediately deploying, and forces in the Philippines.
2. Air combat forces and supporting units.
3. Hawaii and Panama.
4. Antiaircraft defenses in CONUS.
5. Atlantic and Caribbean garrisons.
6. West Coat forces and Alaska.

Forces already deployed were given lower priority than those about to deploy on the mistaken notion that they were already better equipped. Accurate data of on-hand equipment was simply not available. It was not until early 1943 that overseas theaters were given higher priority than deploying units. This led to the anomally of forces engaged in combat (e.g., North Africa) being less equipped than units waiting transport in CONUS. A constant argument waged over the equipping of units in training. Shortages of ammunition led to artillery units training entirely by simulation while tons of ammunition sat in North Africa or the Pacific, where units had not yet arrived to shoot it. Training suffered significantly to the degree that it was decided, arbitrarily, that divisional units would be given at least 50 percent of their equipment. Activation of new units was thus delayed pending ability to equip them. In practice, even the 50 percent could not be sustained, and controlled equipment was issued first to 20 percent of authorized levels and only later to 50 percent, while nondivisional units were often precluded from receiving any controlled items. General Marshall was so exasperated by the process of stripping units in training in order to distribute equipment to other units in training just to equalize shortages, that he wrote it "will wreck the morale of the troops and undermine public confidence." Conflicting policies began to emerge. In the effort to spread the shortages, it developed that there was an insufficient number of units fully equipped and ready to deploy to meet emerging theater operational requirements such as Alaska, North Africa, and South Pacific. The solution was to form a pool of ready units near 100 percent of equipment allowances. Unfortunately, the operational planners designated these ready units far in excess of the logistics system's capability either to equip them or to transport them overseas. OPD's seven-theater sections requisitioned units with little coordination amongst themselves or with G-4. Special operations, such as TORCH, also called for rapid activation of unusual units not in the force trooplist. The repeated plundering of low-priority units to fill higher units froze them in a low-equipment status. Contributing to further chaos was the lack of shipping to move the now-trained units and supplies for buildup of the overseas theater out of CONUS. It was not until 1943 that the construction of shipping began to exceed combat losses. The War Department continued to stick with the philosophy of containing the enemy overseas by "economy of force" while continuing the buildup of a large, fully equipped Army for later combat operations in 1943-44. In a strategic sense, the short term problems of distribution were ignored in the knowledge that in the long term, all would be well. This approach undoubtedly was accurate overall, but contributed to much wasted effort, and also delayed deployment of many forces. The country simply lacked the production capability and shipping capacity to do much beyond wait. There were numerous political squabbles over issues of how much to give Britain and the Pacific theaters. Too much has been made of the Roosevelt/Churchill decision to win the war first in Europe before pressing the war in the Pacific. In fact, analysis of troops and equipment/cargo deployed to the various theaters show a remarkably even distribution in 1941-1943, with the Pacific theaters getting 32 percent of the deployed troops and 28 percent of the supplies, a much higher percentage than MacArthur would have the world believe. OPD apparently elected to support the hot war, not the warming one. There were anomalies--Alaska, for example, received 8 percent of the troops, but 14 percent of the supplies.

<u>Supply versus Transport.</u> Logistics at this time suffered from a division of effort between supply and

transport. The disorganization within the supply system created by shifting priorities and lack of data was contrasted by a rather smooth, efficient transport operation, given the meager shipping that was available. The actual day-to-day decisions on what to ship were made by the port commanders based on calls forwarded by theater commanders. However, the division of effort between supply and transport allowed the transporters to control the flow: their goals were to maximize the use of shipping in terms of weight and cube, and not to ensure the delivery of specific items to specific destinations at specific times. The integration of supply and transport functions received much staff attention in 1942-43.

KOREAN WAR

The literature contains little information regarding strategic logistics in this war, most of it concentrates on logistics in the field. Because the Korean War was the only active theater, and because supply was relatively unconstrained (after initial distribution/transportation problems, the vast WWII surplus was easily tapped), one might wonder about the relevance of this war to apportionment. However, the war was viewed by defense planners as just a single part of overall global strategy, in which the Soviet threat remained paramount. Logistics followed force allocation in the Korean War, but the allocation of forces, and thus their supplies, became a central strategic issue:

how much to give to Korea and the Pacific, versus how much to commit to NATO, when there was not enough to go around. From a planning perspective, this situation is not unlike the present global situation.

Prewar Environment. The logistics situation in Korea prior to the North Korean invasion, 25 June 1950, could hardly have been more disorganized. In the aftermath of WWII, the full attention of the Army turned to the occupation and defense of Europe. The Pacific in general and Korea in particular had been written out of national defense plans. From 1945 to 1950, the primary objectives in the region were to normalize the government and restore economic viability to Japan and liberated regions of the Far East. Military forces in Japan viewed themselves as token occupation forces, and the rapidity with which MacArthur institutionalized democratic government in Japan reinforced the feeling. This led to a distinct lack of combat preparedness. The enormous logistical tail which had been built up in the Pacific during WWII had essentially been left to rust in place. In 1947, MacArthur ordered a reclamation project to begin in Japan to segregate, classify, transport, and repair WWII equipment for storage. However, progress was slow, and by June 1950, 80 percent of the Army's 60-day theater reserves were still unserviceable. No new equipment at all had been received from CONUS since WWII. As occupation troops were deactivated in the Far East, they turned in equipment for war reserves, but most of it was unserviceable. For example, Eighth Army was authorized 226 recoilless rifles, but had only 21 serviceable. Ammunition available was only a 45 day supply (Ref 30:59). By 1950, the growing stability of occupied Japan allowed commanders to turn to improving readiness, but the Army was still "hampered by infectious lassitude, unready to respond swiftly and decisively to a full scale military emergency." (Ref 30:60).

The First Days. The North Korean invasion, 25 June 1950, caught CINCFE entirely by surprise. The next two weeks were taken up by assessment of the situation and determination of the strategy. There had been no plans for the defense of Korea. The extent of American ground force participation in Korea was debated considerably among MacArthur, Collins (CSA), Bradley (CJCS), and Johnson (SECDEF). The piecemeal requests for buildup of forces and equipment without an overall strategic concept was to remain a serious obstacle to efficient prosecution of the war. Truman was intensely concerned that Korea was but the prelude to general Soviet aggressiveness in Europe and was reluctant to over-commit to a possible sideshow. MacArthur argued that the conflagration in Korea was real now and required immediate attention with all resources available. Because the only source of immediate combat power (troops and materiel) was the General Reserve Forces in CONUS, the debate was of considerable importance to the allocation decision.

The active Army consisted of 590,000 of which 140,000 were CONUS general reserves. By the end of July actual and scheduled deployments to Korea had depleted this to 90,000, with MacArthur calling daily for more. No decision had yet been made on strategic priorities. It was not until 15 September that mobilization authority was given, and four National Guard divisions were activated in CONUS. During the summer, as the size of the Army was increased and individual reservists were recalled, there was no coherent logistic strategy for deploying or equipping a force. Logistics decisions were at best a "seat of the pants" affair. In general, resources were not diverted from Europe, but CONUS support bases were severely taxed, and all Pacific transport assets were dedicated to buildup Japan/Korea in necessary stocks and personnel.

Post-Inchon. The success of the Inchon Landings after 15 September radically changed the views of Army logistics planners. As early as mid-October, the war was considered to be all but over, and the frantic movement of supplies and equipment from CONUS began to be diverted, cut off, or targeted for Japanese depots. Thoughts turned to postwar stationing plans, and on 15 October MacArthur was even directed to cancel all requisitions for supply in anticipation of cessation of hostilities. MacArthur's constant assurances that China would not enter the war apparently found receptive ears.

Chinese Invasion. When Communist China attacked with force on 28 November (they had been operating on a piecemeal basis for a month prior to that in North Korea), MacArthur seemed to have panicked. Immediately outnumbered and overwhelmed, the UN forces began their retreat. Defense planners, including the new Secretary of Defense, George Marshall, renewed their emphasis on the defense of Western Europe fearing that too many resources would be devoted to a fight with China at a time they were trying to bolster forces in Europe to meet the Soviet threat (Ref 30:286). The fear of general global war reached its height. The NATO allies were growing increasingly restless. While all this had no direct bearing on the logistics situation, it was still true that logistics followed forces. The Joint Chiefs agreed on 5 December that no new deployment would be made to Korea. However, the materiel losses incurred in fighting the Chinese were critical. So, on 4 December Operation PINK was launched to resupply Korea with an entire division set of equipment, drawn from West Coast units and Mutual Defense Assistance Pact (MDAP) stocks and contingency stocks. MacArthur asked for a second set but was refused. On 15 December Truman finally declared a national emergency as withdrawal from Korea appeared more and more imminent. On 23 December General Walker (CG, Eighth Army) was killed and was replaced by General Matthew Ridgway. Unlike Walker, he was given carte blanche by MacArthur, who adopted a much more detached role with respect to Korea. Ridgway, personally, is generally credited for turning the rout around, re-instilling the offensive spirit and stabilizing the situation by April 1951. Thereafter, the military situation developed into somewhat of a stalemate, amidst some fears that the Soviets would enter the conflict. Throughout the next two years there were sporadic attacks and counterattacks as armistice negotiations dragged on, but these attacks were not decisive and the logistics situation never became critical again.

VIET NAM Vietnam represents a poor case from which to draw any conclusion regarding the apportionment problem. The manner in which it was conducted impacted considerably on logistics to the extent that it is almost a case study in how not to do things.

Military Objectives. The lack of clear political objectives for the war from the very beginning served to prevent a clearly defined, consistent military objective from being formulated (Ref 10:17). A principle result of this was that the war was "managed" rather than prosecuted within the fabric of global strategy. From July 1965 to February 1968, Army strength in Vietnam rose from 27,000 to 320,000, and this was accomplished without any mobilization and under the political constraints of Lyndon Johnson's simultaneous implementation of the "Great Society" program. This placed severe strains on the Army logistic structure and its ability to equip and supply its forces worldwide.

<u>Logistic Constraints.</u> The decision to adopt an essentially static operational concept, coupled with a one-year troop rotation policy, had a decisive effect on logistics: troop comfort became *de facto* the overriding logistical concern. Fully 40 percent of the tonnage shipped to Vietnam in 1965-66 was in facility construction items. No theater standard of living was ever prescribed, so individual commanders sought to give their personnel the highest levels of comfort: food, PX merchandise, refrigeration equipment, buildings, electrical power generation equipment and all the spares associated with such things mushroomed. Tables of Organization and Equipment (TOE) meant little. Without a common standard, the logistics system had no grounds for challenging requirements placed upon it. Hence, in Vietnam the logistics system quickly ran unconstrained, and this was accompanied by financial constraints upon the Army overall. The resulting squeeze meant that the Army in Europe in particular, but also in CONUS and Korea, suffered severely in logistics readiness throughout the war. The experience of the Korean War was turned upside down. In Korea, the threat of global war was so great that planners refused to allocate resources to Korea, a perceived sideshow, at the expense of the Army in Europe. In Vietnam, a known sideshow, resources were diverted from Europe and elsewhere, placing the Army at severe risk in meeting any global threat.

Impact on the Active Army. The lack of an apportionment plan which reflected global strategic priorities created severe problems for the units not in Vietnam. Diversion of resources from the major Army commands to Vietnam in 1965-66 had the following effects (Ref 10:251).

1. Only 35 percent of Continental Army Command units met equipment on-hand goals, and only 25 percent met equipment status (maintenance) goals. Only 40 percent of U. . Army Pacific units met equipment on-hand goals, and only 18 percent met equipment status goals. U.S. Army Europe was 66 percent for equipment on-hand and 50 percent for equipment status. The majority of combat units outside Vietnam were rated C-3 (marginally ready) or C-4 (not ready) on unit status reports. Both combat divisions in Korea were C-4.

2. Prepositioned War Reserve and POMCUS Stocks (Prepositioned Materiel Configured to Unit Sets) were reduced substantially in Europe and Korea. War reserves in the Pacific were nearly depleted. Recovery did not occur until 1971.

3. Reserve and National Guard units were tasked to redistribute equipment to Vietnam. Two hundred aircraft, 460 40mm guns, 50 tank recovery vehicles, and 650 trucks were among the items withdrawn. Most of the Reserve and Guard units fell to C-4 during this period.

LESSONS LEARNED.

The apportionment problem that faces logistics planners today is much more complex than that faced in previous wars. Both Vietnam and Korea were single theater wars in which concern for other possible theaters was real but not critical. World War II provides the best example of apportionment planning and actual allocation, but the war was fought with the luxury of time to prepare before commitment to combat in multiple theaters. Nevertheless, there are some broad lessons that can be learned from the historical record of these wars.

1. Coherent Planning Strategy. In planning for multi-theater conflict, it is a necessity to have a coherent strategy; one that is capable of providing the logistician with sufficient guidance but requiring little situational modification. The WWII example of establishing the buildup in Europe as the primary logistics objective was such a strategy, although there were numerous short-term deviations from this strategy. The role of political decision making at the highest level in the strategy process cannot be overemphasized, since any global strategy that is not fully in accord with political objectives is worthless for planning purposes. We have observed how the efforts to "Americanize" the war effort in WWII detracted from strategic decisions. Vietnam provides an example of how divergent political and military objectives hindered

coherent strategic planning.

2. Realistic Stable Priorities. Inherent in developing sound strategic plans is the necessity for establishing global priorities, and then, barring major changes in the strategic situation, sticking with those priorities. In WWII there were many short-term changes in priorities which nearly created chaos in the logistic system. In the long term this could have been prevented by following the original strategic plan.

3. Coalition Warfare. The necessity for incorporating allied logistics requirements into strategic planning is apparent. In doing so, the political sensitivity to our own operational capability should not be ignored.

4. Funding vs Requirements. It should be taken as an axiom that funding for logistics will never match requirements. This is true both during the planning phase (peacetime) and allocation phase (wartime). Even during the height of WWII, the inability to fund logistics and the inability of the mobilization production base to meet requirements forced a drastic rescaling and deferment of operational plans. The need for identifying the proper priorities with the knowledge that full requirements will never be met becomes even more important.

5. Accuracy of Planning Factors. As the duration of a possible conflict decreases the necessity for accurate logistic planning factors increases. With little time

to react in a short war, the logistics decisions made well prior to the outbreak of hostilities are, in effect, irrevocable decisions.

6. Shipping Overrides Apportionment. The most severe limitation on any apportionment scheme is the availability of shipping assets. In no past conflict involving ocean movement was shipping ever available in sufficient quantity to logistically support initially devised operational objectives. In this light, apportionment makes little sense if the means to deliver are not there. In WWII, this limitation was overcome by time--two years of nonstop ship building. A 180-day conflict will in essence be a "come as you are" war.

7. Remember the Training Base. Any apportionment scheme must take into account the needs of the training base, which include mobilized but not yet deployed reserve components. The effects of "robbing Peter to pay Paul" must be carefully evaluated to balance immediate operational needs against the value of having an equipped proficient force available at M+60.

8. Logistic Intelligence. The utility of an apportionment plan depends on the accuracy and availability of detailed information concerning the asset status and requirements in each theater. This necessitates a uniform reporting system (not yet in place), common agreement as to definitions and terms (e.g., what does it mean to say "I have X amount in

Theater War Reserve?"), and a common method among theaters for estimating and stating requirements.

9. Allocation Follows Systems. History is full of examples of the wrong supplies arriving in the wrong theater on the basis of unexamined supply requirement tables. An absurd example is cold weather clothing going to the South Pacific. A more costly example, operationally speaking, is large-bore artillery ammunition arriving in Africa with no large-bore weapons in the force structure to fire it. Apportionment must be geared not only to the force structure scheduled for a theater but also to the particular weapons system destined for the theater.

Scope and Assumptions

The following assumptions are made to set the scenario of the problem:

1. A commitment is made to fully support a given contingency, after which a second contingency (or multiple contingencies) requiring logistic support develops (Ref 29).

2. The materiel support for these multiple contingencies exceeds the available resources, including many high technology weapons systems.

3. The movement of materiel is supportable by the Defense Transportation System, with limits on the maximum amount deliverable between destinations (Ref

40).

4. This study will examine intra-CONUS (Continental United States), inter-theater shipments handled by military airlift, and sealift.

5. This study will focus on selected critical supply items in Classes V (ammunition), VII (major end items), and IX (major component parts), but the methodology wil be capable of adding other classes of supply and substitute items (Ref 2:2).

6. The strategy for filling each theater's demands will be set with the second contingency having greater national interest.

7. This study will cover the period extending up to the first 90 days of U.S. combat in the first theater to open.

8. Forward-stationed war reserves normally will be dedicated to the theater in which located, although transfer of selected items from one theater to another is permitted (Ref 42:56-57).

Methodology

The problem structure involves finite sources and assets, large quantities of demands, route selections, and time factor considerations. There are no historical examples of concurrent contingency plan execution, and field experimentation is not feasible due to economic constraints. One approach to its solution is through the use of Computer

Simulation Analysis.

A computer simulation model can be designed to analyze the flow through the supply-and-demand process on an incremental time step basis, and identify major item delivery time, intermediate points of travel, time spent at these intermediate points, the visibility of the items enroute, and the cargo accessibility for diversion to alternate locations (Ref 21:2-5). Also, computer simulation modeling has the capability to monitor the shipment process over time, and permits mid-shipment destination changes that are not possible in pure transportation alg rithms (as these are based on optimizing delivery between two set points). Further, computer simulation modeling allows the use of samples from specified distributions for action/reaction times. Because of its flexibility and time response capability, simulation will be used instead of a transportation algorithm or a network analysis. Additionally, a complete mathematical formulation of the problem appears infeasible (Ref 23:147).

The simulation model will capture the interaction of the system processes that will be addressed later. The model's reference framework will require the following information:

1. Development of a segment to act as Department of the Army guidance. It must simulate Joint Chiefs of Staff (JCS) priorities and issue Office of the Deputy Chief of Staff for Operations (ODCSOPS) directives. The basis for the guidance and directives will come from DARCOM and ODCSOPS. This

interview information will provide guidance for:

a. OPLAN/LOGPLAN priority--to delineate which plans, on a competitive basis, take priority over other plans in the distribution of limited items.

b. Critical item priority--the interview information will be used in conjunction with the recently compiled (May 1983) consolidated listing of critical items for all contingency plans, to determine the ranked impact of common critical items. (These inputs are indicated by (A) on Figure 1).

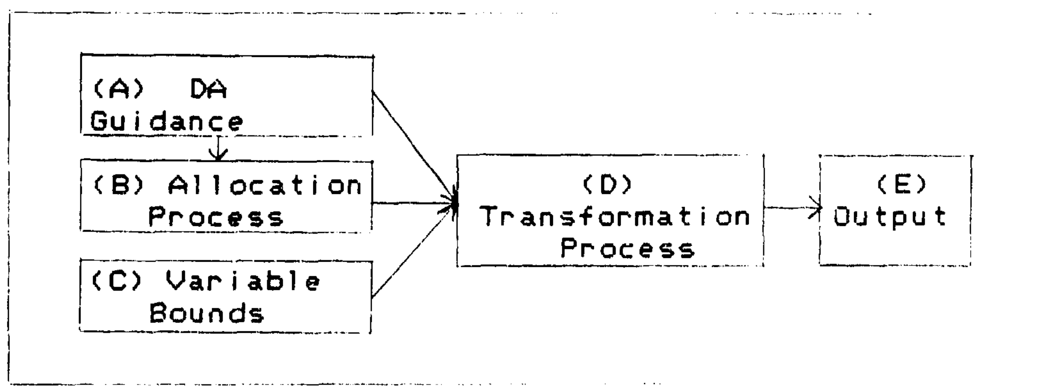


Fig. 1 Simulation Model Schematic Diagram

2. Development of an allocation segment to handle apportionment of critical items. It must simulate ODCSOPS decisions on apportionment of limited resources to the mutually competitive contingency plans. This information was obtained from CAA and DARCOM by interview, and used to

develop the allocation model.

3. Development of a realistic bound of variables. The framework parameters will be based on:

a. Transportation network determination. The defined network will include CONUS and overseas (sources) storage locations of stocked materials, the CONUS depot collection points that are used to consolidate (and package as necessary) contingency plan support shipments, and typical aerial ports of embarkation for each depot, intermediate transit/refuel/layover points, and delivery location (Ref 8). Additionally, typical routes between points will be defined, as per type carrier (commercial truck, air, rail) for each leg (Ref 20:61).

b. Supply item stockage level. The inventory amount will be based on stocks already available, new acquisitions, and amount of stocks consumed. The rates of new acquisitions and consumption will be based on probability distributions.

c. Processing and delivery time determination. The time periods that will occur include:

(1) Conversion of requisitions to material release orders for transmission to depots and supply sources.

(2) Depots and supply sources pick, pack, mark, and ready supplies for shipment.

(3) CONUS transit times from supply sources to Consolidated Containerization Points (CCP) for shipment to contingency areas.

(4) CCP processing and cargo consolidation.

(5) In-transit time from CCP to Aerial-Port-of-Embarkation (APOE).

(6) APOE processing and cargo loading.

(7) In-transit time from APOE to APOD (at the forward destination) (Ref 41:77-83).

(8) APOD unloading and pick-up times.

These times will be based on contingency LOGPLAN guidance, and follow a probability distribution.

d. Route Sequences and Rates of Travel--typical shipment routes, from depot storage location by transit route to port of embarkation (POE) and delivery at port of debarkation (POD), will be obtained from DARCOM and MAC.

e. Flow Capacities--amount of shipping capacity, for MAC delivery legs, that is possible between air lines of communication will be obtained from MAC support annexes to the various contingency plans. (These inputs are indicated by (C) on Figure 1).

The simulation model (item (D) on Figure 1) will take the basic inputs, do an initial assignment algorithm, and start the shipment process to deliver the item from CONUS depot to overseas POD. The model will track the cargo in time, as it has the travel movement rates, and at the point of strategy change (a new contingency erupts), it will halt the delivery process, re-orient to a new delivery point, and recompute the assignment algorithm. The model will have to consider communications time lags, location of the cargo, and diversion of the shipment carrier to a new destination. The model will output (item (E) on Figure 1) the quantity delivered within preset time windows, by flexibility strategy. This output will then be used in decision analysis, to determine the optimum strategy to support the given contingencies.

Overview of Thesis

The next five chapters present the model development, policy evaluation, and conclusions and recommendations.

Chapter II describes the model development. Within this chapter, a description is given of how key parameters were developed, assumptions used, and how the various parts of the model were integrated into a system.

Chapter III contains a discussion of the computerization of the system model.

Chapter IV discusses the verification of the functioning of the model and also the validation of this model.

Data Collection and Analysis in Chapter V discusses experimental design and sample size determination.

Included in Chapter VI are the conclusions drawn from this study and also the recommendations from this study.

II. System Structure

Introduction

The U.S. Army logistics policy of rapid response, when combined with increasing supply acquisition shortfalls, has caused the development of an inflexibilitiy problem; the supply "train" cannot readily adapt to rapidly changing situations. The most crucial of these situations is that of multiple contingency plan execution.

To determine what can be done to regain flexibility in the U.S. Army logistics system for it to adequately support execution of multiple contingency plans, new flexibility measures are necessary. The processes and operations of the U.S. Army logistics system and the interactions of these new measures within the environment of that logistics systems must be studied and understood. Once these systems are conceptualized and modeled, the output results must be analyzed for relative impacts.

New Policy Conceptualizations

In order to resolve the problem of inflexibility due to responsiveness, it is necessary to determine which system structures allow this problem to exist. On the surface, it appears that automated data processing has so accelerated the demand-and-fill processing procedures that the system no longer has significant time lags and, therefore, very little flexibility (Ref 29). However, analysis of the supply systems' underlying policies reveals additional contributing factors. Currently, demands are filled on a first-come-first-serve basis, with only minor priority delineation (UMMIPS - Uniform Materiel Movements and Issues Priority System). These demands are based primarily on the type of activity (in combat, designated forces for deployment within specified time periods and the urgency of need) of the unit initiating the request (Ref 3:2-1). However, the requisite document number must be properly coded to penetrate the Reserve Purpose Coded stock; then they will be issued first-come-first-serve till all stocks are expired (Ref 40). Additionally, of the total global inventory of on-hand stocks, only stocks in CONUS depots are considered to be readily available for global dispersion. Those stocks that are positioned outside of CONUS, while being very available to their immediate location, are not viewed as immediately accessible to another global theater, and then only after considerable high level coordination. Further, the inventory on-hand is viewed as available for issue to all customers, and will be issued, first-come-first-serve, until all stockpiles are exhausted. This includes many DOD warehouse facilities that hold inventories for particular agencies, but are not prohibited from issuing that inventory to a different service agency, upon receipt of demand. Each of these policies is geared to rapid response and, when combined with the available hardware, has nearly eliminated all possible flexibility.

To build some flexibility into this system, it is necessary to design and implement policies that will change this basic structure. These policies can be viewed as either of two types; (1) changes to the structure that are effective before the item is issued, or apportionment policies, and (2) changes to the structure that are effective once the item is in motion on the delivery network, or diversion policies. Any potential policy changes must have an automation capability, or be considered as inappropriate for the magnitude of the problem.

Apportionment Policies

When demands exceed available supply, on any scale, the decision maker controlling the inventory goes through a judgemental process to determine who is supplied first. Businesses usually resolve this by supplying the highest bidder. Military operations need an equally powerful ranking system, an urgency of need/combat intensity system. This priority system is based on the supposition that arriving demands are filled on a cyclic basis (daily, hourly, whatever is desired), and these demands are forced to queue before being served. The combat intensity priority value will rank the waiting unfilled requests, so that the most important request is filled first. The assigned priority value is based on the combat intensity being experienced by the requesting unit. An example of this type of scale is:

Priority	Low			Medium			High		
Numerical Value	1	2	3	4	5	6	7	8	9

The assignment availability of different values on this scale is decision-maker directed, and should be based on the following:

1. The intensity and potential of the threat forces in the engagement. This requires an analysis of the enemy's potential employable combat power, his commitment to fighting U.S. forces, and the amount of time it would take him to utilize his forces.
2. The contingency plan being supported. Each contingency plan is designed to support specific global locations, and each location has some degree of national interest. This step requires a comparison of the relative interest levels between the various contingency plans.
3. The relative stability of the conflict. Several plans are based on the concept of initiation of operations, a surge period for attainment of principle objectives, and a follow-on or mop-up phase. Correspondingly, demands from different phases of the operation should have equally distinct urgency requirements.
4. The type of unit making the requisition and their combat status. This is an expansion of the UMMIP

system, and includes both the unit type (Infantry, Armor, Artillery) and its employment at the time of request (training, transport, committed to combat). Additionally, there is a need for a priority upgrade measure, to be applied on an elapsed time basis, to permit an unfilled demand to have its priority raised so that, after an appropriate period of time, it can rise to the top of the list, and be filled. This upgrade process will preclude one plan, though in a stabilized condition, from being totally shut-off from supplies. This rate of improvement can be assigned simultaneously with the initial priority level.

Other allocation policy changes are directed at the handling of on-hand inventory. The first policy requires a change in the inventory utilization perspective. All assets, both CONUS and other than CONUS (OCONUS), must be viewed as having some degree of global availability. CONUS assets, the primary inventory, will continue as being usable at any global location. OCONUS assets, those in various preposition locations, will have a primary end-point destination (its theater of prepositioning), and a series of secondary locations that they can be used in (Ref 35:10-11). This is a conditional availability with the following restrictions:

1. Of the total stockage in a prepostioned location, there is a minimum inventory level that is to be held for the primary location. Any amount above that minimum

level is available to the secondary locations. (This amount can be determined from inventory records, and could be an adjustment to the number of days of on-hand supplies.)

2. The secondary locations will be rank ordered for each proposition location, and will be ranked on a basis of distance and delivery capacity. Certain locations may not be supportable from particular preposition locations.

This global availability concept is designed to increase the amount of readily usable on-hand materials.

The last allocation policy to be examined affects the primary inventory, the CONUS stockpiled assets, particularly those items identified as critical supply items. To judiciously issue critical items to only the most needy units requires a policy that limits the amount of inventory that can be released under particular circumstances. This is a policy of "fencing" inventories and it is similar to the previously mentioned minimum stockage level concept. For this study it will be based on total inventory stockage levels. This policy can be incorporated through use of existing project codes, that are assigned to the various inventories, and implemented by decision-maker directives to free assets of a particular code once specified contingency conditions have been met (those being time, unit commitment, or other desired basis). The desired impact of this policy is to have something to issue to an important reque:

Diversion Policy

Once all of a particular inventory is committed, in motion to various respective locations, and an urgent request is received, the request must be either held until new acquisitions arrive, or a moving shipment diverted to fill that urgent request. The variations in military cargos significantly complicates the feasibility of implementing a diversion policy, but, with the following restrictions, it could be made workable:

1. Only a limited number of items are considered as feasibly being divertable. The diversion candidates are those items which, when packaged, containerized, and palletized, retain a homogenous nature. The purpose for this is to eliminate the need to break open a pallet or container to find a single item. Typical items are class V items (ammunition), class VII items (major end items), and class IX major component parts (engines, transmissions) (Ref 40).

2. Only point-type diversion will be attempted, and then only within CONUS boundaries. The transportation network involves several processing points, as well as transportation legs. A comparative analysis of the times spent processing versus transporting indicates that there is a greater probability of "catching" the cargo at a transit point than while it is enroute. The CONUS boundary limitation is added as transportation

assets and information passage are much more responsive here than outside of CONUS. This combination causes each transit point to be viewed as a dynamic, time-sensitive resource location (a mini-depot).

3. Only extremely high priority requisitions would be considered as diversion requirements. The priority designation can be either the combat intensity priority previously discussed, or the current UMMIPS designator. If the priority exceeds some predetermined level, the system will begin polling the transporation routing scheme, in a predetermined order, to determine if there is a divertable shipment and, if possible, execute the diversion.

The diversion process is only possible if timely location information is available for moving shipments. The Logistics Intelligence File (LIF) is currently set-up to receive image reproduction of transactions documents as the shipment moves to its destination (Ref 6:3-3). An enhancement to the LIF system could provide the monitoring information (running tab by inventory item) per transit location that would be the necessary source data for the divert decision. Additionally, to prevent any transactions from being lost, an interface with the automated processing system (CCSS) is required to provide automated cancellation of the initial release order, fill of the high priority request, and reorder of the first requisition. Currently, the Transportation Routing Index (TRI) has the capability, with extensive manual manipulation, to divert routed cargos on a limited basis. The proposed conceptual system is designed to provide an automated capability, and will be used for study purposes.

System Conceptualization

The development of new flexibiliy concepts for the U.S. Army logistics systems required a new conceptualization of the system as a whole. Within the development of this new structure, allowances were made to permit full implementation and experimentation of the new policies. The task accomplishment required examination of how the new policies interact with the processes of the logisitics system, observation of the systems resultant behavior, and measurement of the relative impacts for further analysis.

Structural Model

The concepts developed in the previous section are designed to provide timely allocation, and if necessary, diversion of critical items of supply. The concepts can be briefly summarized as:

1. Priority designation system, based on urgency of need/combat intensity.
2. Limited global availability for all on-hand inventories.
3. Controlled release, or "fencing", of critical item inventories.

4. Diversion of routed cargos to fill extremely high priority requests.

However, these concepts cannot be properly exercised without additional information inputs to the DA/JCS decision-making authority. These decision-makers also require information on global situations and stockage considerations. The global situation data is needed to determine the relative importance between competing demand generation locations. Historical records, present tendencies, and future prediction are used to determine each location's urgency of need. The stockage data includes on-hand inventory, its global location, new acquisition amounts and anticipated delivery dates. Figure 2 depicts this information flow network, and how these inputs contribute to the evolution of the apportionment and diversion policies. Within the two policies, the new concepts are feasible.

The task of modeling a system is eased if a pictorial representation can be made of that system. Figure 3 provides such a picture, in the form of a causal loop diagram. This visual depiction of the U.S. Army logistics system is an abstraction, and as such requires the modelers to define those elements included in the model.

Within the causal loop diagram, all relationships, except for the two policies, are measurable in terms of unit cargos. Feedback indicates that relationships can influence each other; however, feedback does not have to exist even when direct relationships do exist. Positive and negative

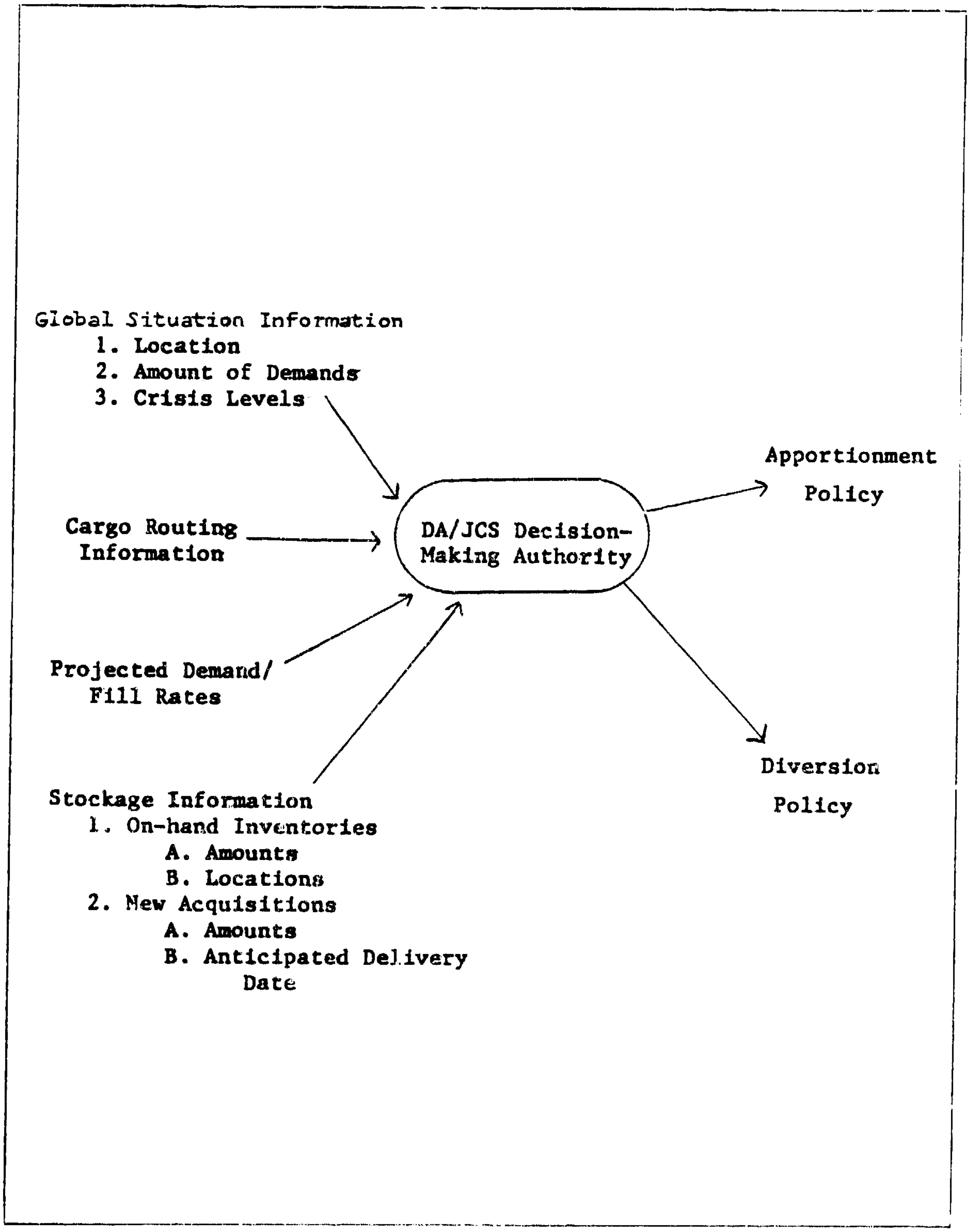


Figure 2. Information Flow Network

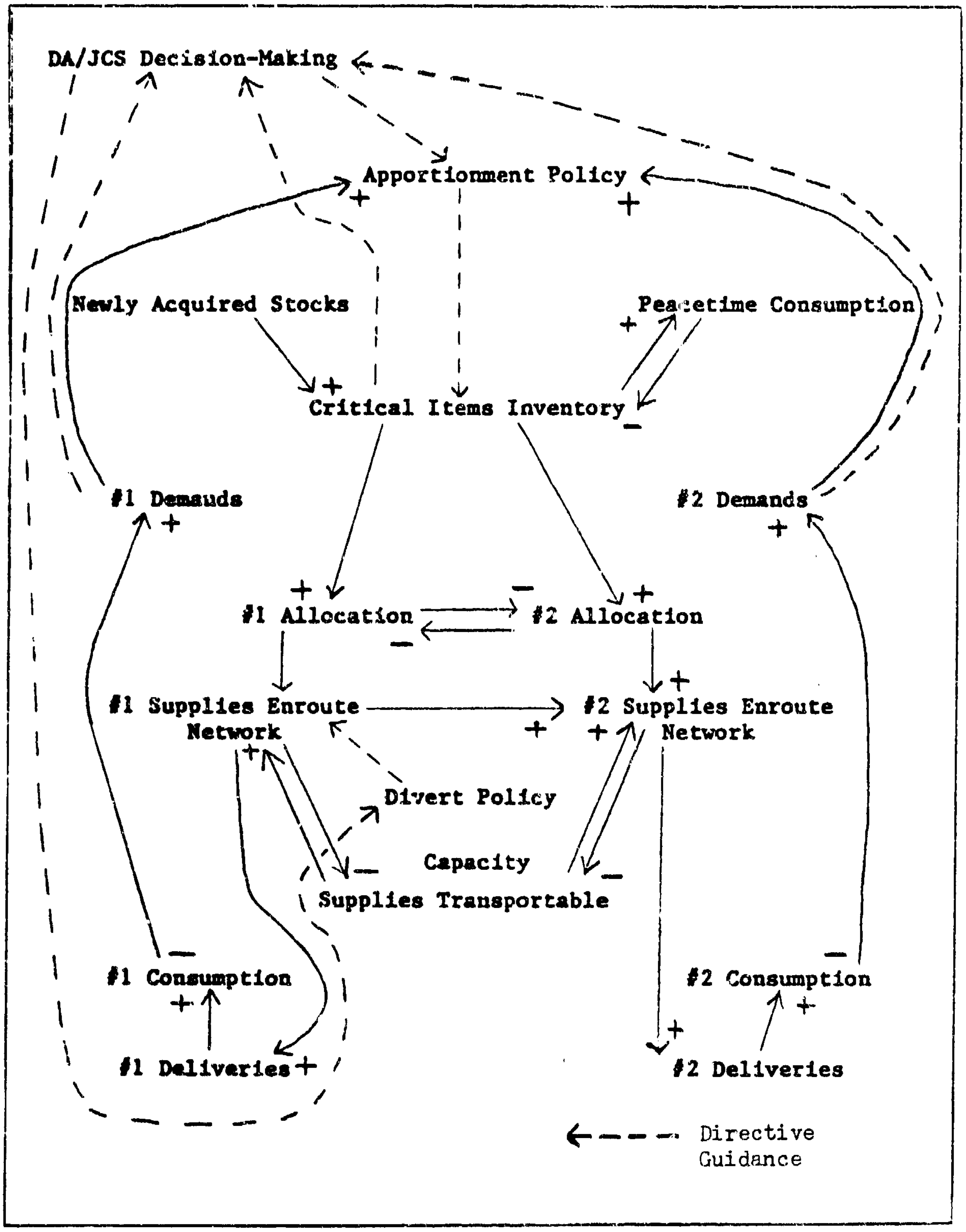


Figure 3. Modified Causal Diagram Contingency Support System

signs on the arrowtips indicate positive and negative correlation between increases and decreases of variables in the same loop. A net sign is found by multiplying all the signs within a loop. A positive net sign shows that the relationships within the loop continue to increase unless restrained by an external factor. A negative loop seeks equilibrium when acted upon by an external force (Ref 5).

Examination of the relationships begins at the Apportionment Policy, the result of a transformation of inputs by the DA/JCS Decision-Making Authority. The apportionment policy is the directive guidance as to how the Critical Item Inventory is to be disbursed, and as guidance, it is more appropriately described as an information relationship than as an activity interaction. Conversely, the Critical Items Inventory relationships (with Newly Acquired Stocks, Peacetime Consumption, Location #1 Allocation, and Location #2 Allocation) are all direct activity interactions. All Newly Acquired Stocks contribute positively to the amount of Critical Items Inventory, while the other three reduce the amount of Critical Items Inventory as their own quantities increase. The relationship between Location's #1 and #2 Allocations is such that as the amount of one is increased, the other decreases, this due to the limited amount of total inventory available. The remaining relationships, with one exception, describe the flow of cargos to ultimate destination, their consumption, and resultant initiation of new demands. The exception is the relationship of Locations #1 and #2 Supplies Enroute, and the Diversion Policy. The Diversion Policy, as well as the Apportionment Policy, is directive guidance from the DA/JCS which switches the end location of a moving cargo. For this experiment, Location #2 will be the receiving destination and Location #1 the losing destination, thus the one-way descriptive sign. This diagram assists in the conceptualization and formulation of the system simulation model.

Summary

Chapter II has described how the problem was conceptualized in order for the computerization to be structured. The apportionment and diversion policies were discussed. In addition, restrictions upon the structural model were discussed.

Chapter III describes the computerization of the conceptualized structural model for multiple contingency logistic support.

III. Simulation Model Description

Introduction

Pritsker's Simulation Language for Alternative Modeling (SLAM) was selected to serve as the test vehicle for this simulation experiment. SLAM is a powerful simulation language that provides the user with multiple capabilities to model networks, discrete events, continuous events, or any combination of these three processes. Since the system's basic structure is a network base with discrete event decision processes, SLAM's flexibility provided the opportunity to model the system as a network with event nodes. The discrete event processes, representing changes of state within the system, were modeled within the event nodes utilizing user-written FORTRAN subroutines. The reader is referred to Introduction to Simulation and SLAM (Ref 22) for a more complete description of the language and SLAM's capabilities.

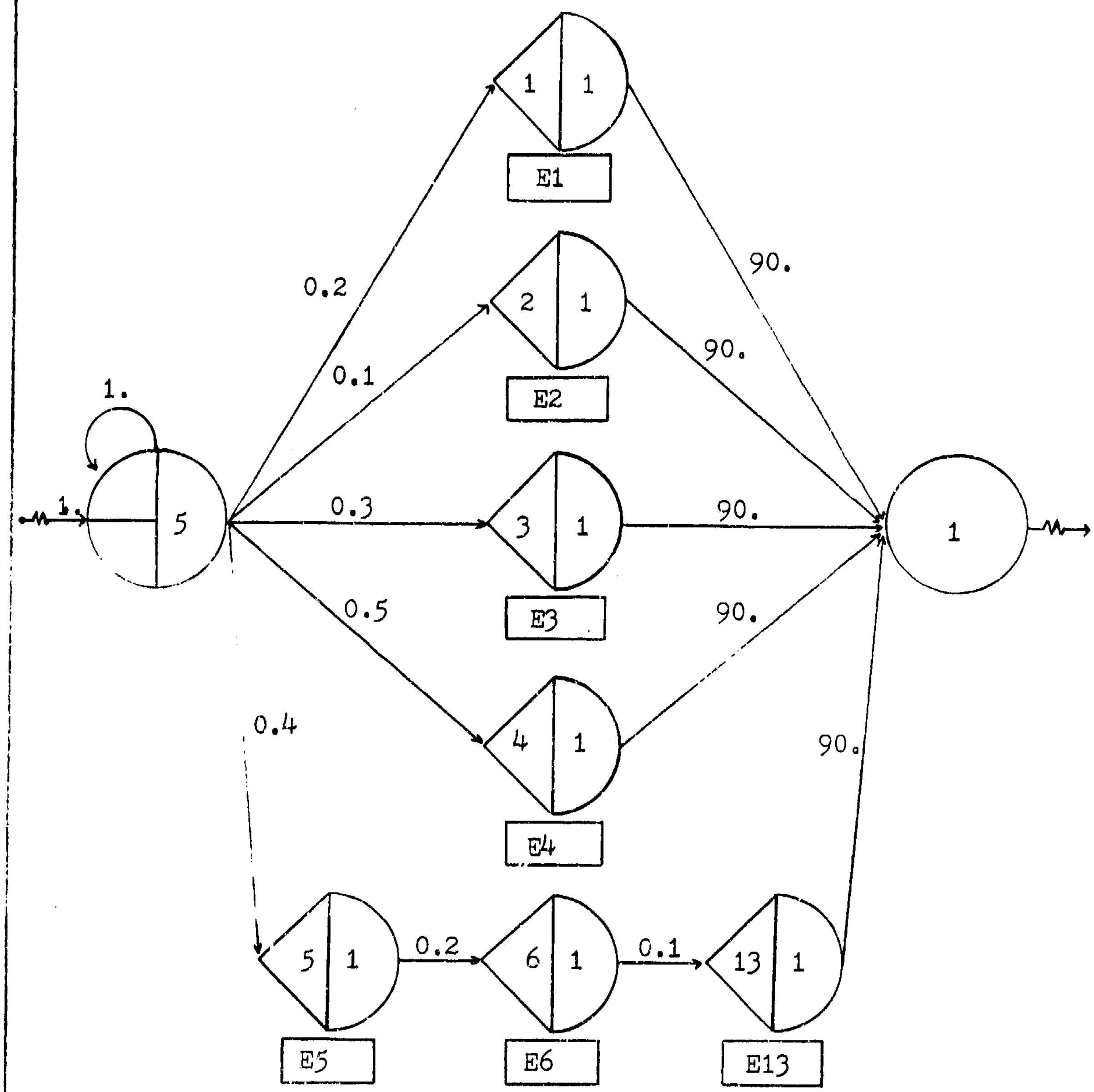
SLAM Network

The SLAM network was divided into five inter-related subnetworks: (1) clock/generation subnetwork, (2) CONUS apportionment subnetwork, (3) OCONUS apportionment subnetwork, (4) recycle/divert subnetwork, and, (5) transportation subnetwork. The networks and FORTRAN subroutines interactions will be discussed in the following sections.

1. Clock/generation subnetwork. This network, depicted

in Figure 4, is used to establish the operating cycle of the experiment and generate the demands and supplies available for the system. The time unit established for the simulation was one day. Once each day, new requisitions were created and portions of the total inventory were made available for issue. Event nodes 1 and 2 were utilized to generate demands for destinations 1 and 2, respectively. Event nodes 3 and 4 were used to determine how much on-hand inventory was available, per day, from CONUS and OCONUS sources. The products of these four generations were inserted into the second network, the CONUS apportionment subnetwork, for handling of the supply-and-demand process. The entities were created and assigned attribute values to match requisitions and supplies, keep track of a particular type of item, and route cargos to final destinations.

Event nodes 5, 6, and 13 are used to route unfilled requisitions through the full cycle of fill possibilities and are sequenced to execute daily. Event 5 is called after all CONUS resources have been utilized. Any unfilled demands are removed from the CONUS apportionment subnetwork, and entered in the OCONUS apportionment subnetwork. Once OCONUS resources are utilized, event 6 is called to remove any unfilled requisitions from this subnetwork, and enter them into the Recycle or Divert subnetwork. Similarly, after all recycles and diverts are accomplished, event 13 is



Events
1. Generation of location #1 Requisitions.
2. Generation of location #2 Requisitions.
3. Determination of daily available CONUS Inventory.
4. Determination of daily available OCONUS Inventory.
5. Unfilled requisitions movement, CONUS → OCONUS fill.
6. Unfilled requisitions movement, OCONUS fill → Recycle or Divert Network.
13. Unfilled requisitions movement, High priority requisitions to recycle.

Figure 4. Create / Generation Network

called to remove any unfilled high priority demands, and recycle them for the next day.

The generation of entities, and their cyclical movement through the system follows this daily pattern shown in Table 1.

TABLE 1

Time	Event
.0	Create node releases (any recycled requisitions arrive in their appropriate queue nodes).
.1	Location 2 requisitions are generated and arrive for queueing.
.2	Location 1 requisitions are generated and queued.
.3	CONUS inventories are made available (requisitions and items matched and processed).
.4	Unfilled requisitions are moved from CONUS-fill to OCONUS-fill queues.

.5 OCONUS inventories are made available for selective use.

.6 Unfilled requisitions are moved from OCONUS-fill to Recycle or divert network.

.7 Unfilled high priority requisitions are moved for recycling to next day.

1.0 All recycles are scheduled to arrive at CONUS fill queues at 1.0.

End of daily cycle.

2. CONUS Apportionment Subnetwork. This network depicted in Figures 5a-j, receives inputs from the user-written event subroutines and performs a cycle of operations simulating the supply and demand process. The first process in this network is the rank ordering of all demands, based on a highest-value-first (HVF) assessment of the combat intensity priorities. These values are assigned as entity attribute two. Next, the demands are matched with entities representing CONUS supply assets. The matched transactions are then branched for destinations, and, using Accumulate or Go On nodes, consolidated from individual items to pallet

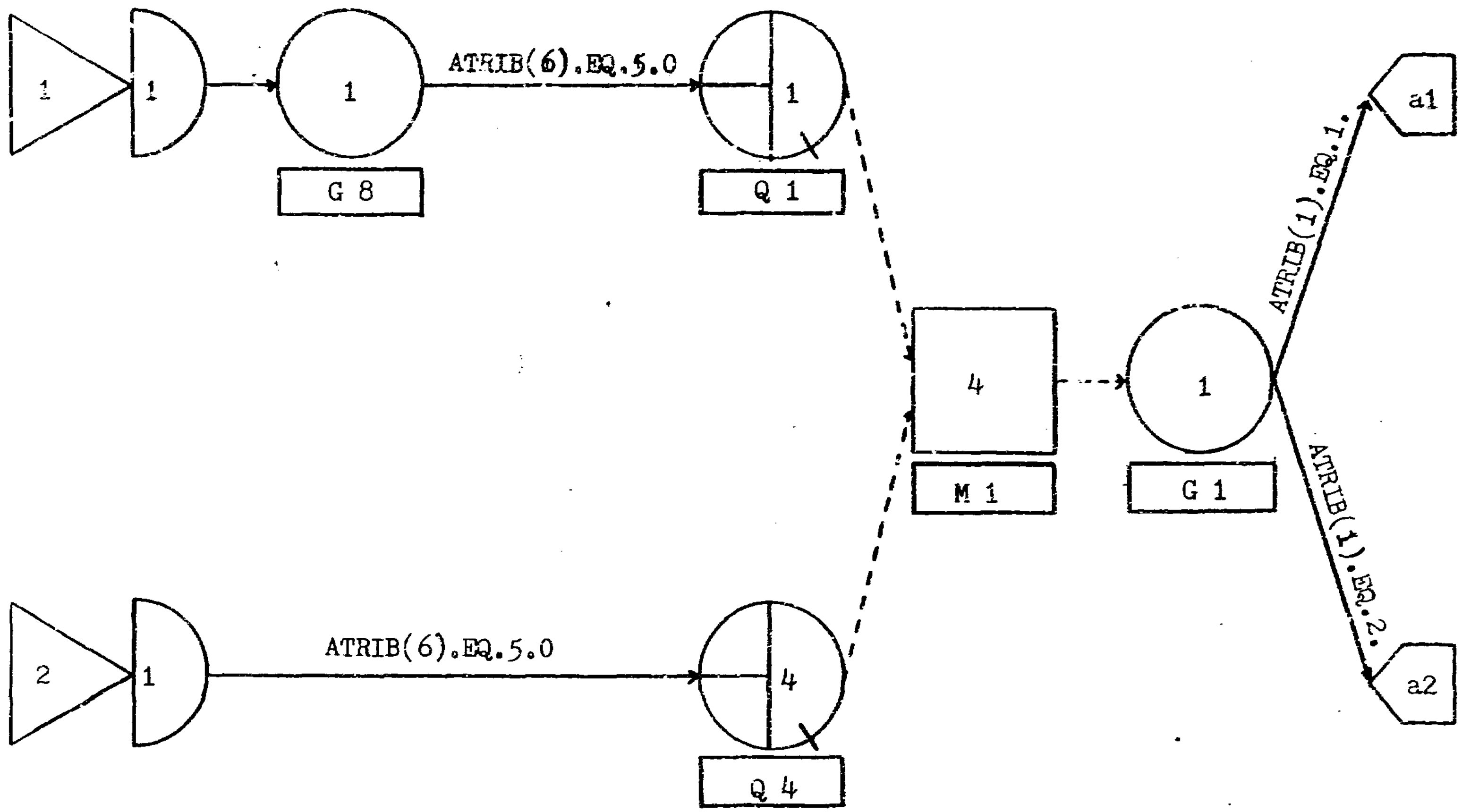


Figure 5.a. CONUS Apportionment Network, class V requisitions fill process.

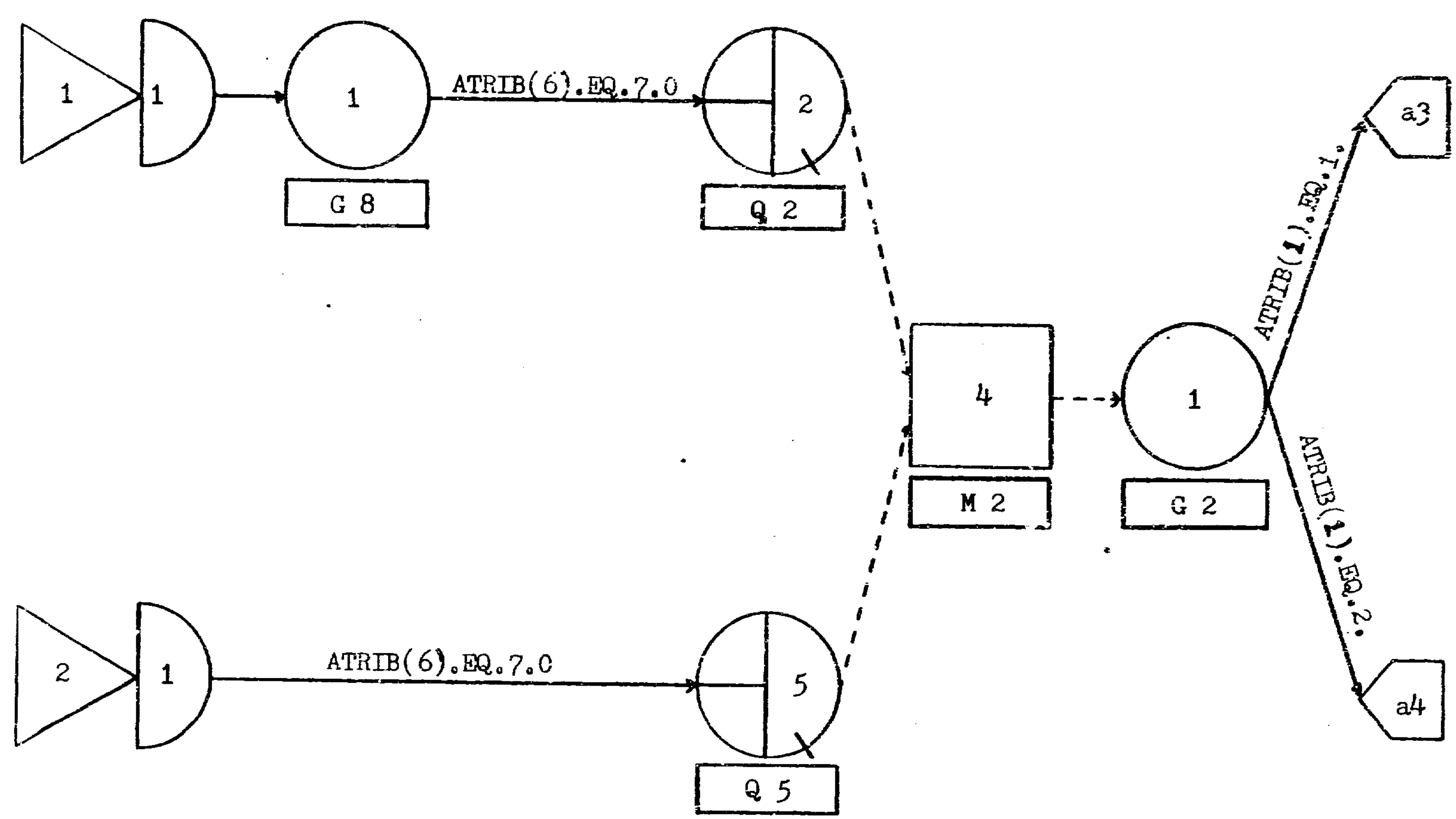


Figure 5.b. CONUS Apportionment Network, class VII requisitions fill process.

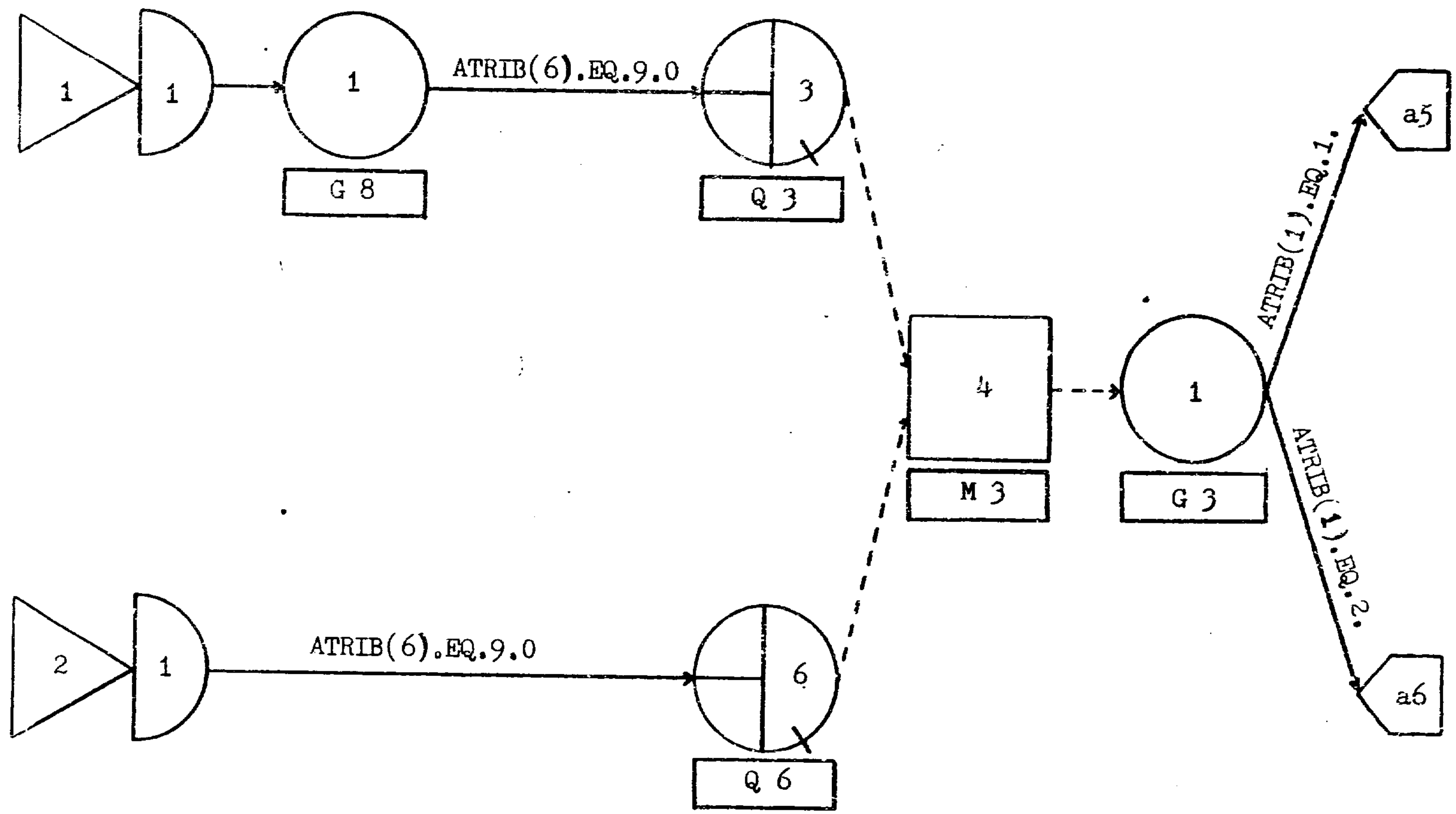


Figure 5.c. CONUS Apportionment Network, class IX requisitions fill process.

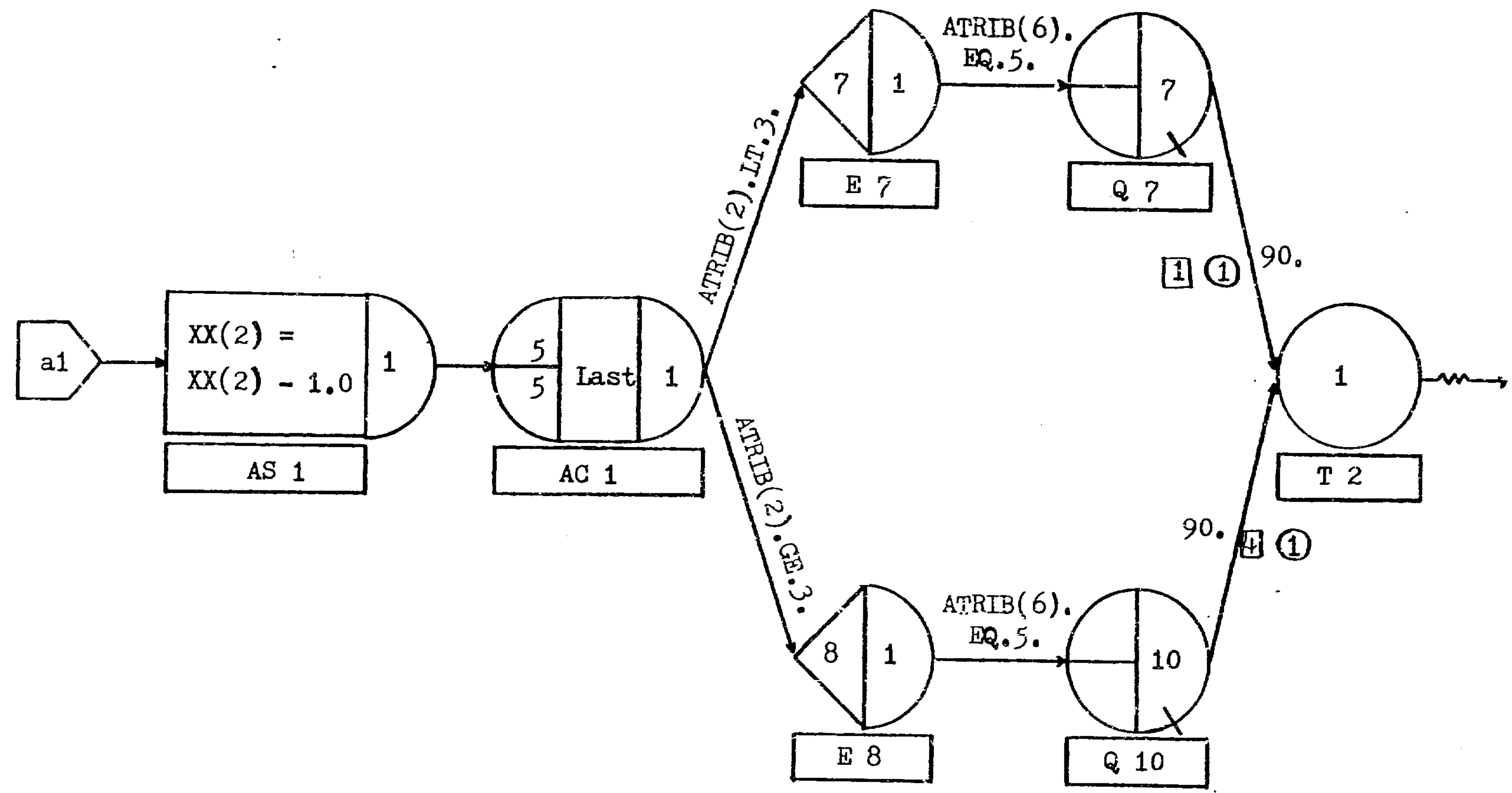


Figure 5.d. Class V Inventory Adjustment, Destination #1 airlift and sealift cargo consolidation.

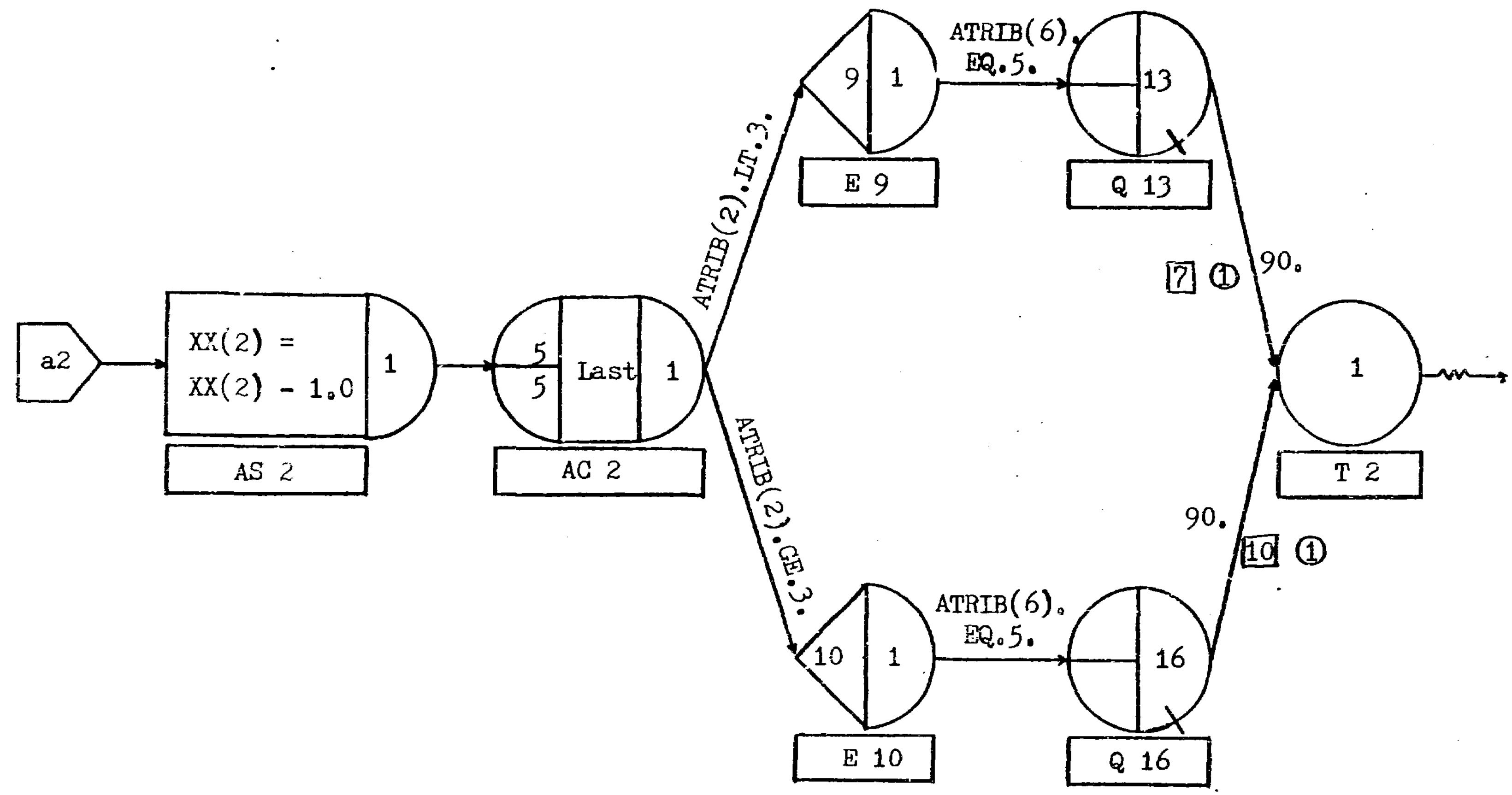


Figure 5.e. Class V Inventory Adjustment, Destination #2 airlift and sealift cargo consolidation.

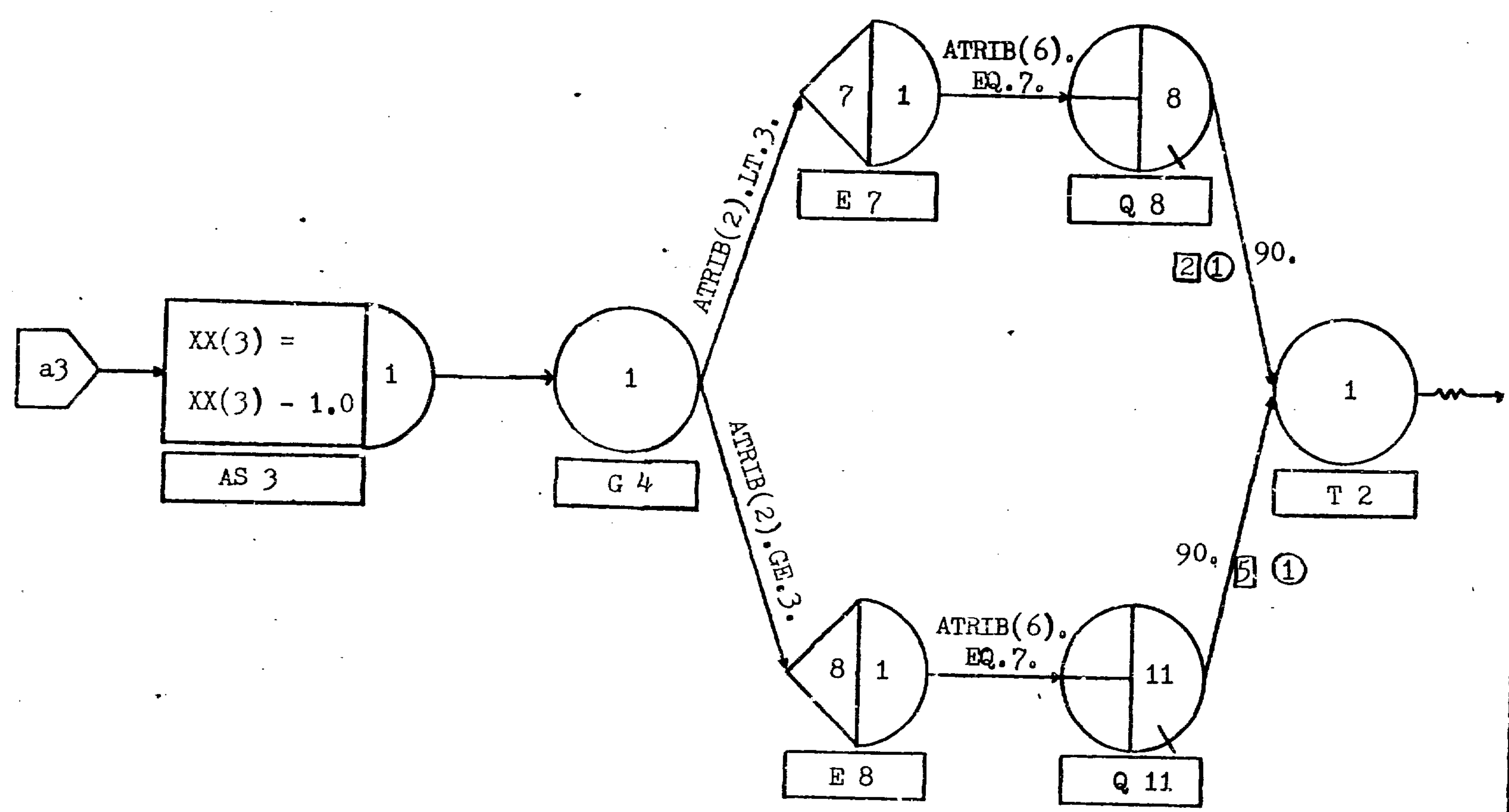


Figure 5.f. Class VII Inventory Adjustment, Destination #1 airlift and sealift cargo consolidation.

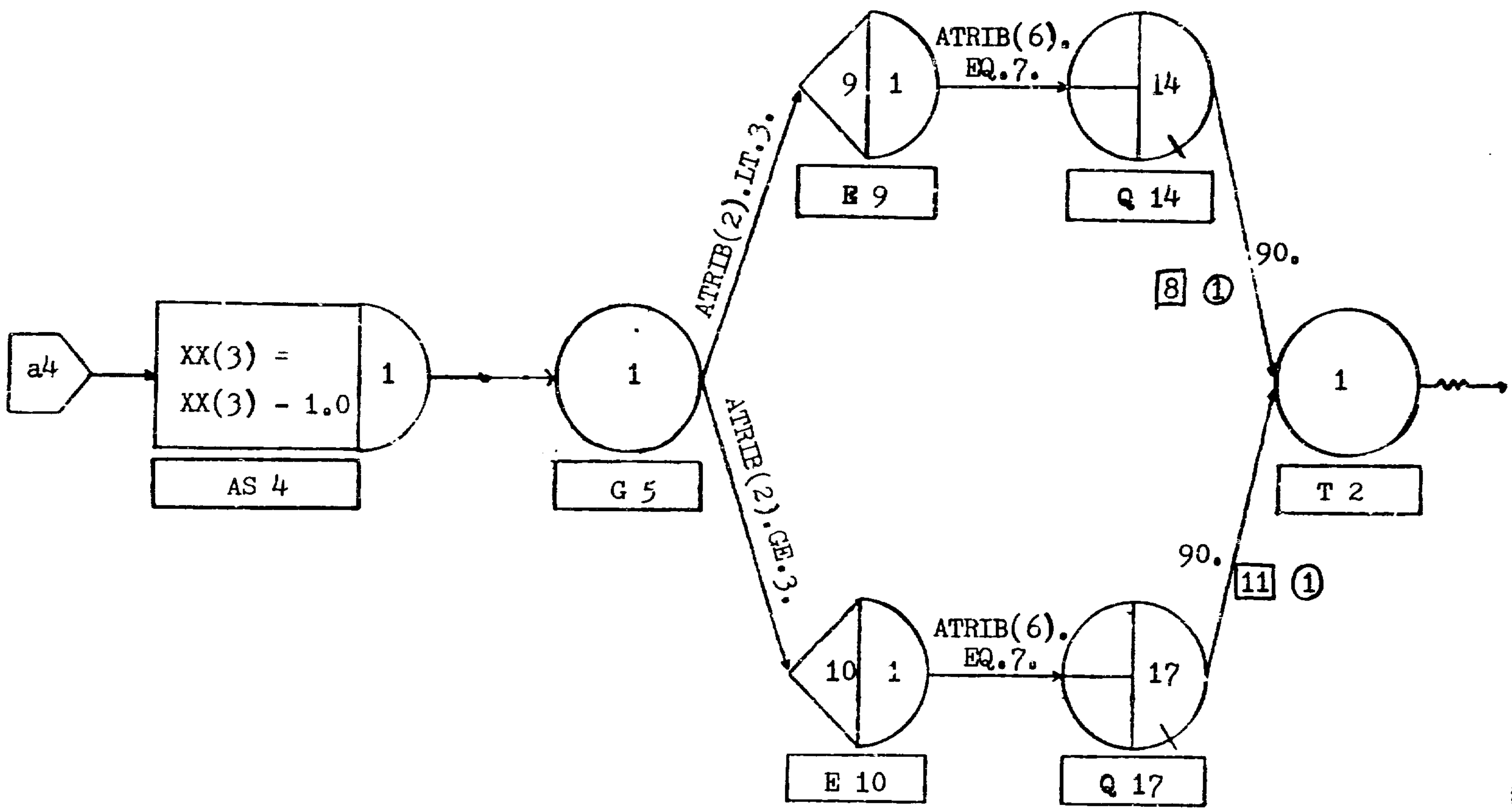


Figure 5.g. Class VII Inventory Adjustment, Destination #2 airlift and sealift cargo consolidation.

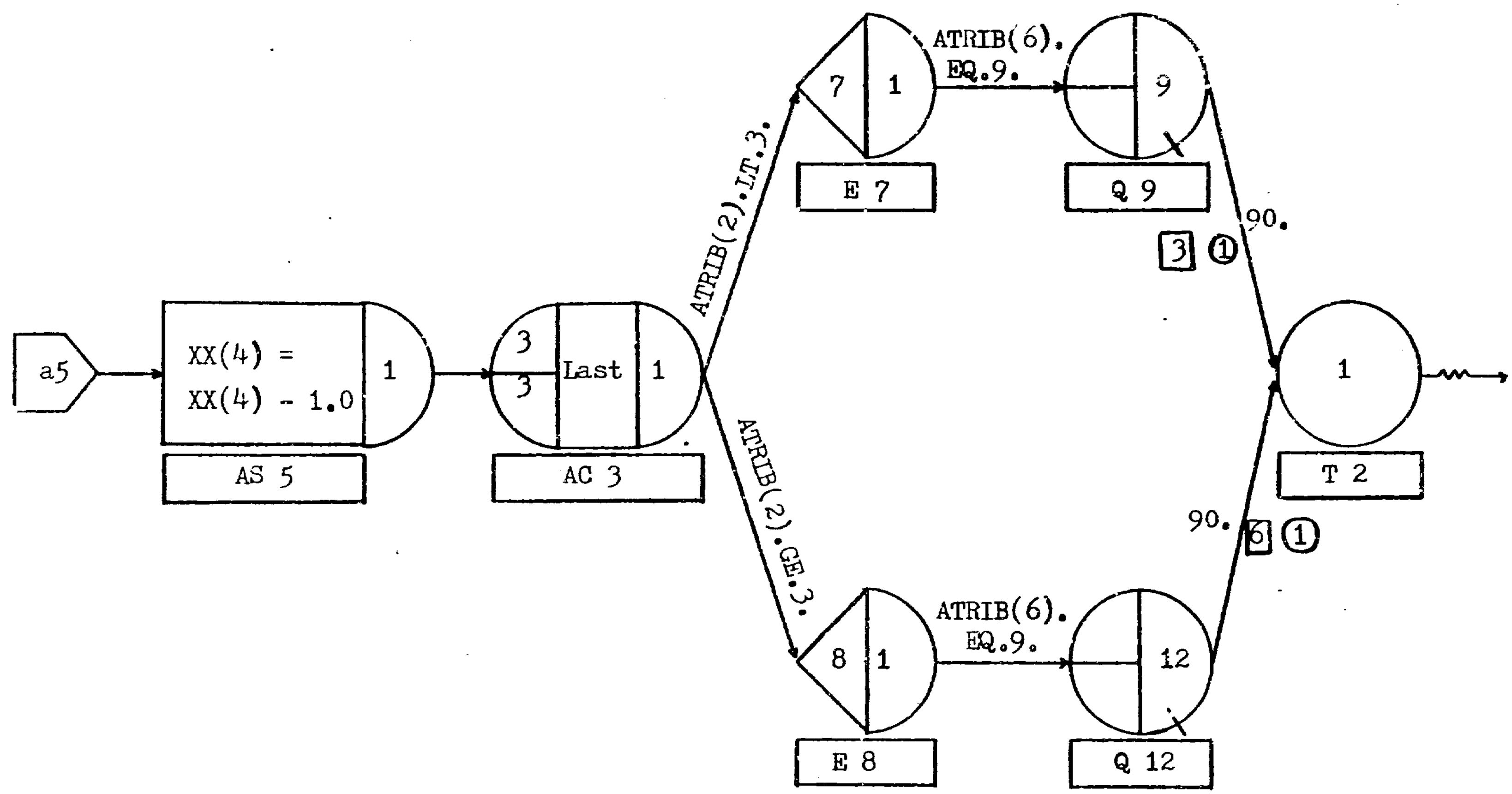


Figure 5.h. Class IX Inventory Adjustment, Destination #1 airlift and sealift cargo consolidation.

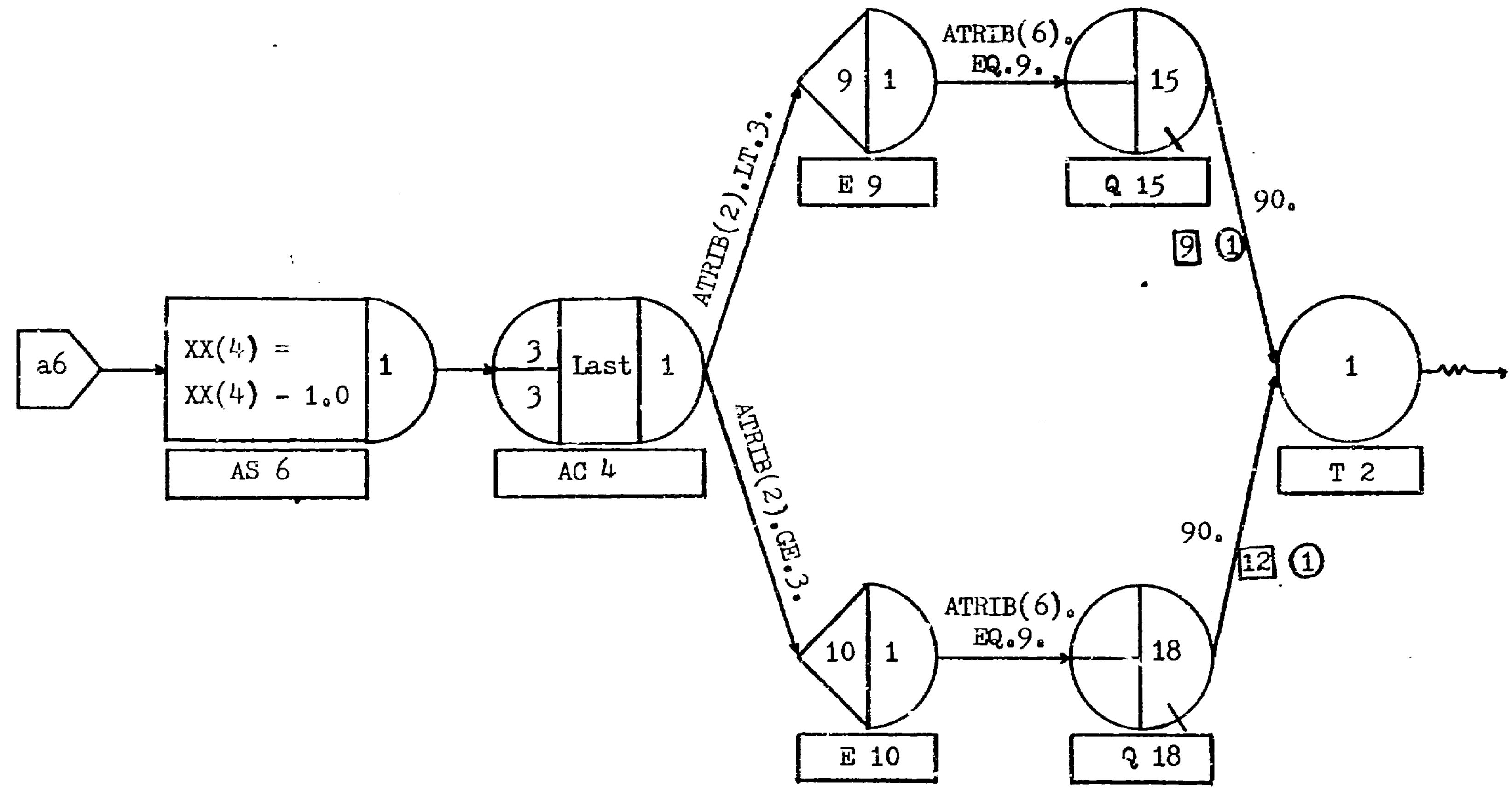


Figure 5.i. Class IX Inventory Adjustment, Destination #2 airlift and sealift cargo consolidation.

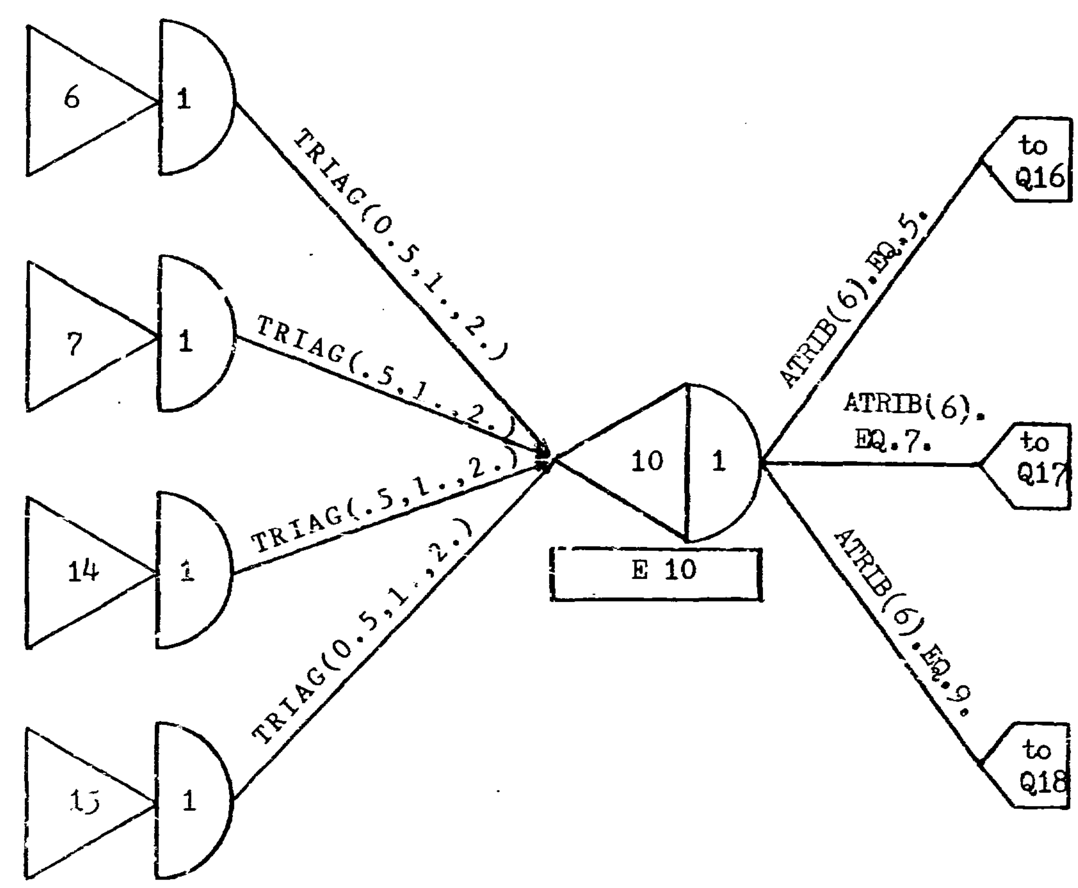


Figure 5.j. Diverted cargos re-entry to delivery channels.

loads for transportation. This first process represents actions at a CONUS-based materiel/storage site, the fill of requisitions, palletizing the cargo, and shipping to a Consolidation and Containerization Point (CCP). The arrival of palletized cargos at the CCP's are simulated by entities arriving at event nodes 7, 8, 9, and 10. The nodes represent CCPs for sealift and airlift to location 1, and sealift and airlift to location 2, respectively. Once a planeload or shipload is configured, the entities are removed from this subnetwork and a single entity, carrying attribute values for the item quantitites, is entered into the transportation subnetwork. Figure 5j depicts the process that diverted cargos use to re-enter the transportation system. Enter nodes 6, 7, 14, and 15 represent cargos diverted from destination #1's sealift CCP, airlift CCP, sealift POE (Ref 18:21), and airlift POE, respectively.

3. OCONUS Apportionment subnetwork. This network, depicted in Figures 6a-d, operates once all transactions have been made for CONUS available assets. The unfilled requisitions, in the CONUS Apportionment subnetwork, are withdrawn from the CONUS fill queues, and are placed in OCONUS fill queues. The requisitions, as in the previous network, are ranked by the combat intensity priority and processed for fill by OCONUS assets. The matching process in this network is the same as that

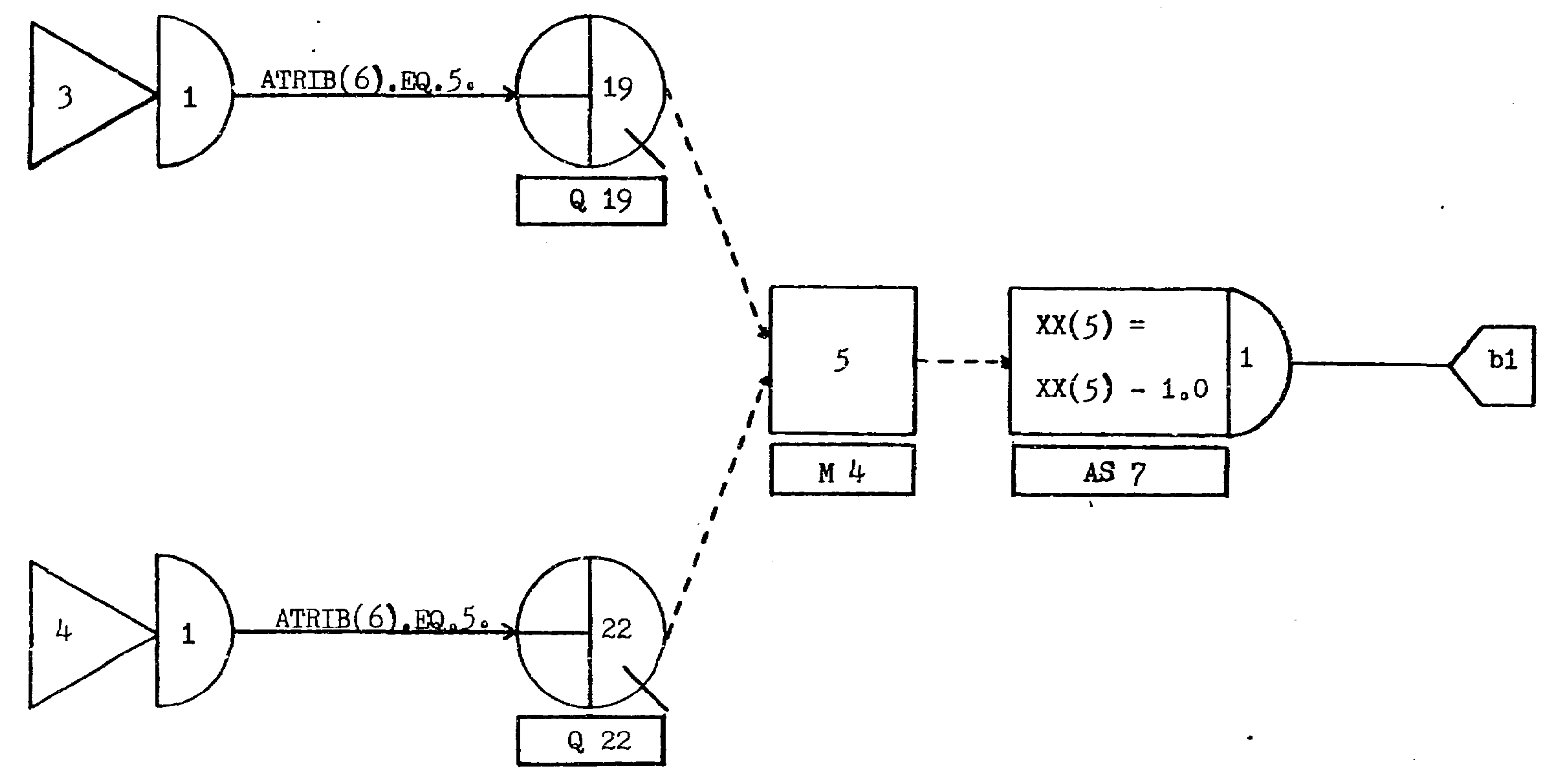


Figure 6.a. OCONUS Apportionment Network, class V demand-fill process, and inventory adjustment.

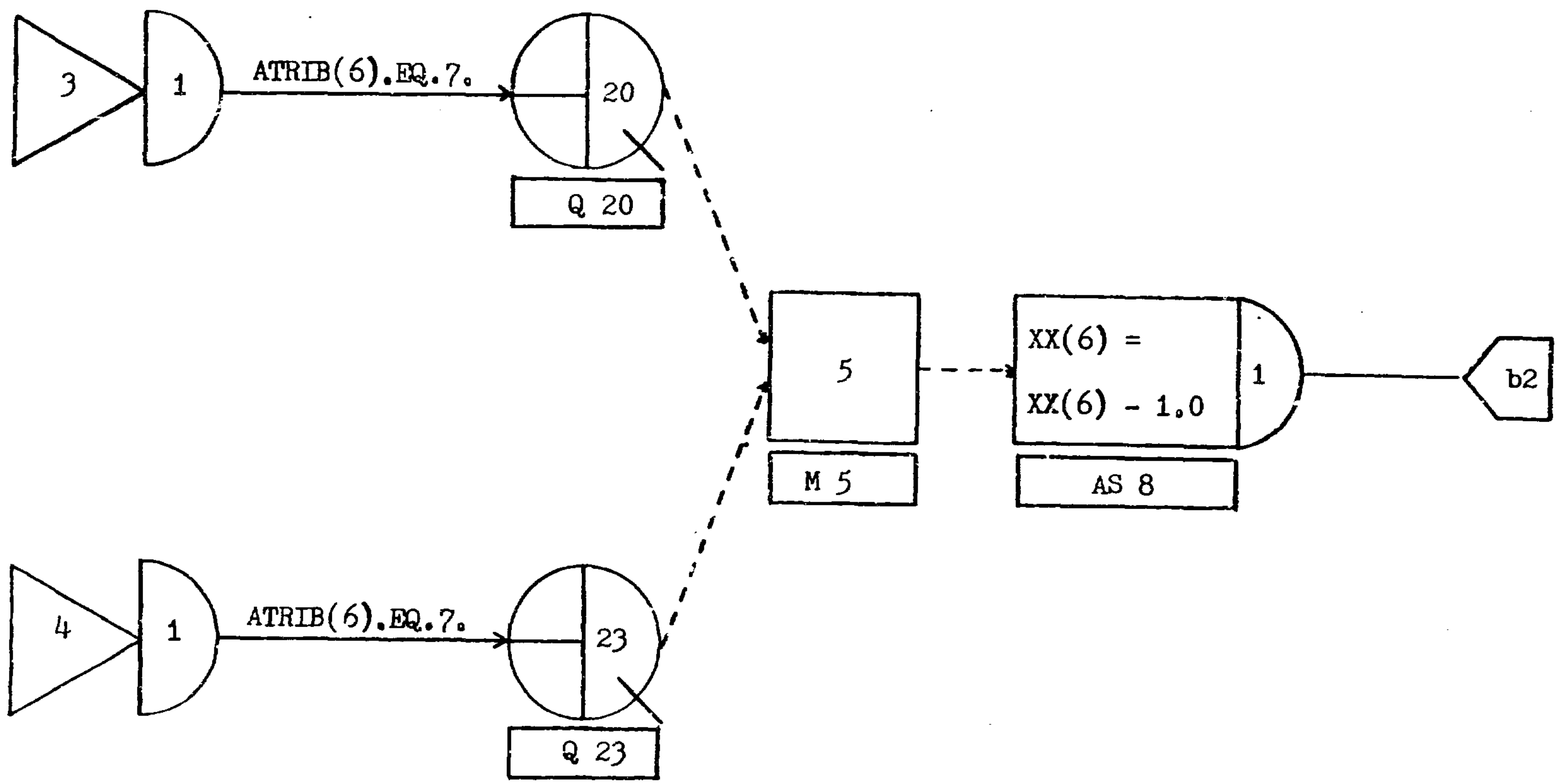


Figure 6.b. OCONUS Apportionment Network, class VII demand-fill process, and inventory adjustment.

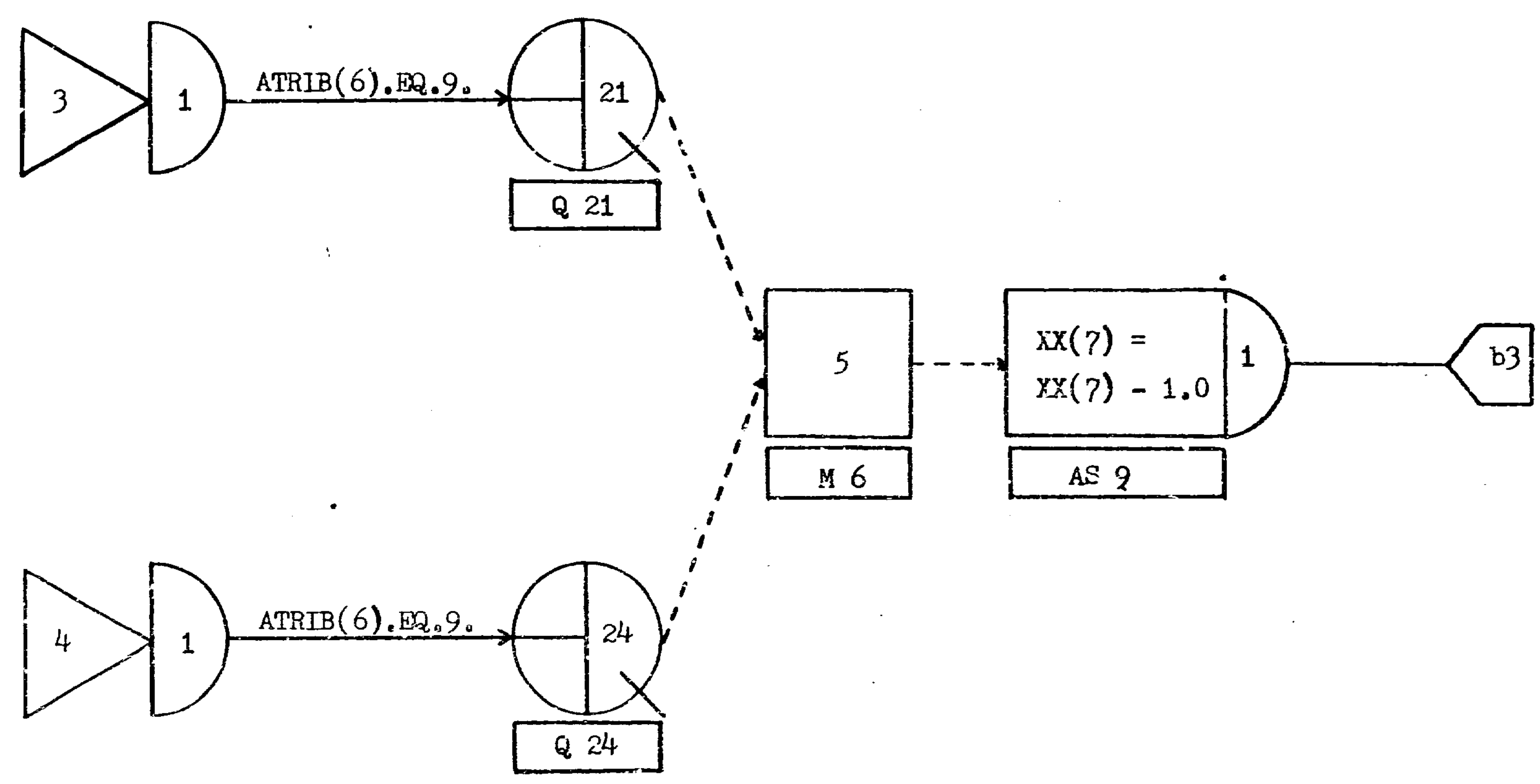


Figure 6.c. OCONUS Apportionment Network, class IX demand-fill process, and inventory adjustment.

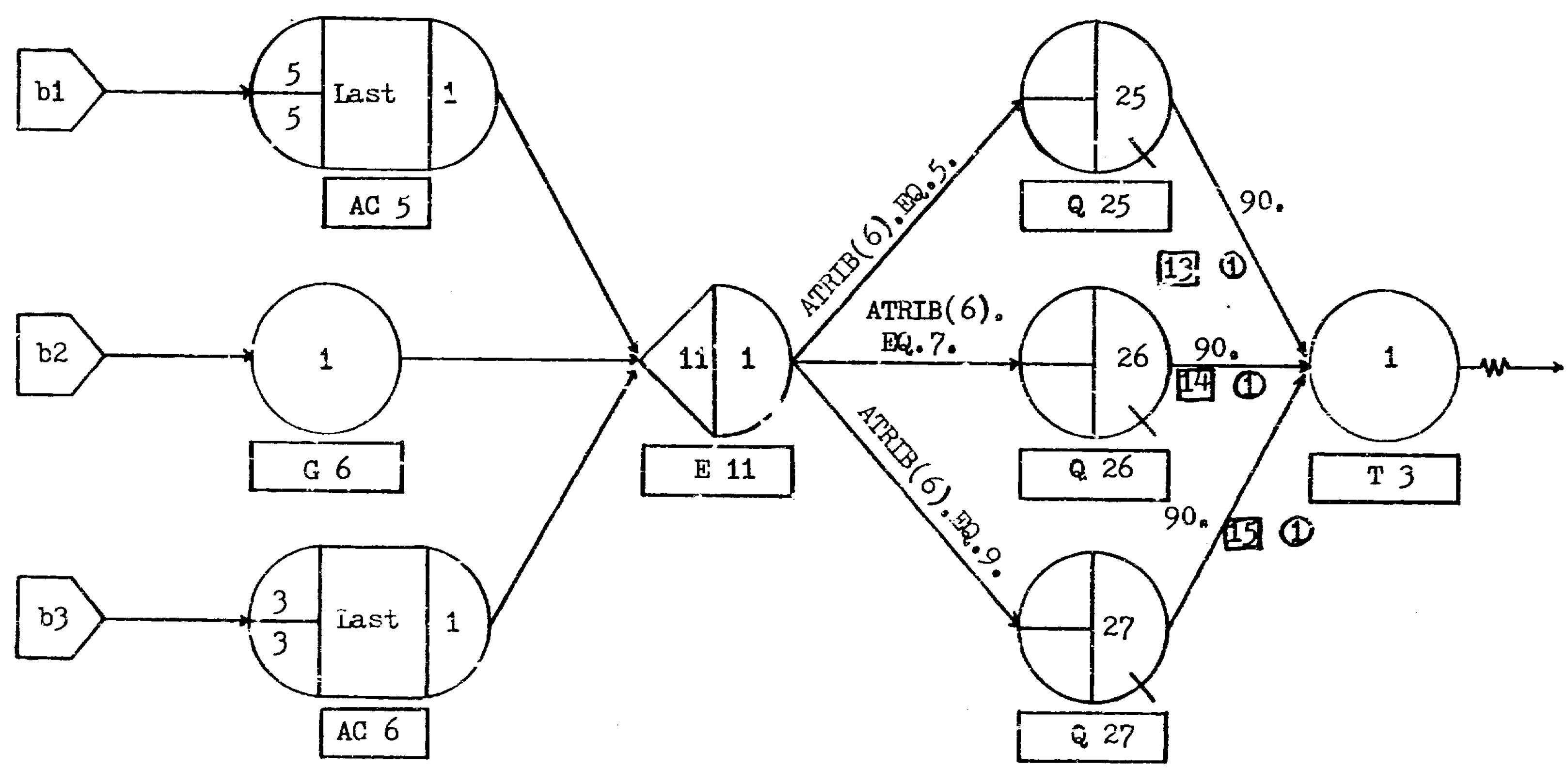


Figure 6.d. OCONUS Apportionment Network, cargo consolidation for airlift.

used in the CONUS network, except the matchup is keyed to a different entity attribute. The matched transactions are palletized and configured for shipment, but will be moved by airlift only (as opposed to both air and sea lift). The configured shipments are then entered into the transportation network.

4. Recycle/divert subnetwork. This network, depicted in Figure 7, processes the handling of a particular day's normally unfillable requisitions. The first step is a check for possible fill-by-diversion requirements. If there are enough requests, of sufficiently high priority, and for the destination of greatest interest, the diversion subroutine will be executed.

The unfilled demands that are not keyed for diversion, either due to destination or low priority, are then routed through a priority adjustment process and recycled. The unfilled requisitions go through an assignment process where its combat intensity priority value is incremented, and are then scheduled to arrive at the CONUS apportionment network at the start of the next day's operational cycle. This process permits a low priority request to gain sufficient worth, over a period of time, to come to the top of the queue and be filled. Also, varying the improvement increment rate will cause some low priority requests to rise faster than others. Once diversion considerations are completed, the unfilled high priority requisitions are

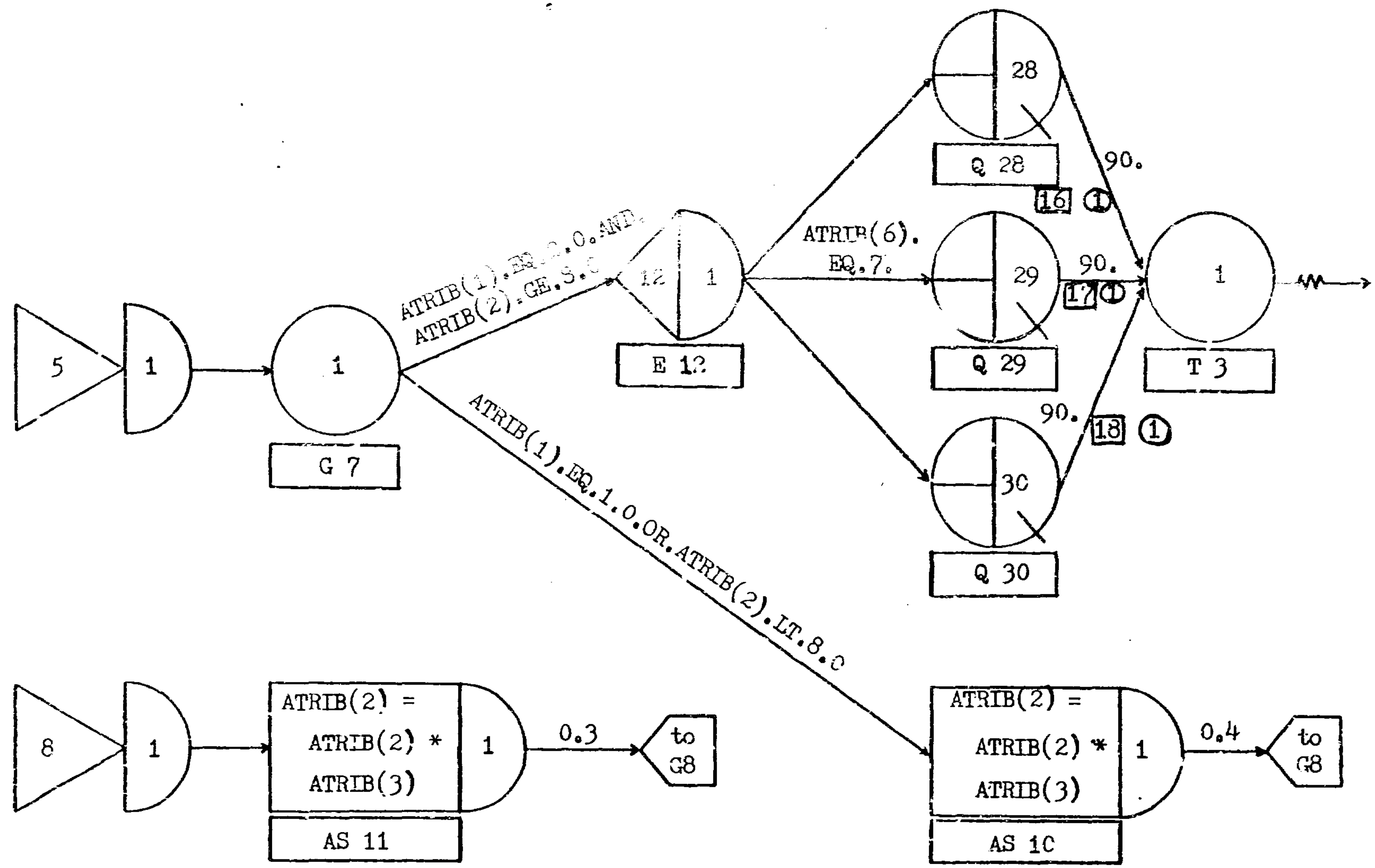


Figure 7. Recycle / Divert Network.

similarly processed and recycled.

5. Transportation subnetwork. This network, depicted in Figures 8a-i, represents the cargo transit network from CCP's to respective end-point destinations. This network represents intermediate point processing times as well as travel times. An entity entering this network represents a consolidated load leaving a CCP. Its first activity is representative of the travel time required to move the load from CCP to POE. At this point, the configured loads are processed for movement from POE to ultimate destination. The queue nodes represent the processing required at the respective POE's. The Colct nodes represent the forward location of the requesting units. As the quantity of an item type in a given cargo load is recorded as an attribute value, it is possible to monitor a cargo enroute by "catching" it in a queue node and reading the desired attribute. This capability is essential to efficient diversion of moving cargos.

The varying entry points represent air and sea lift for each destination. The entry points are nodes 9 for sea POE for destination 1, 10 for aerial POE to destination 1, 11 for SPOE to destination 2, and 12 for APOE to destination 2. Each of these points are CONUS based. The last branch represents the movement of pre-positioned items from one OCONUS theater to another.

The Colct nodes collect statistics on number of

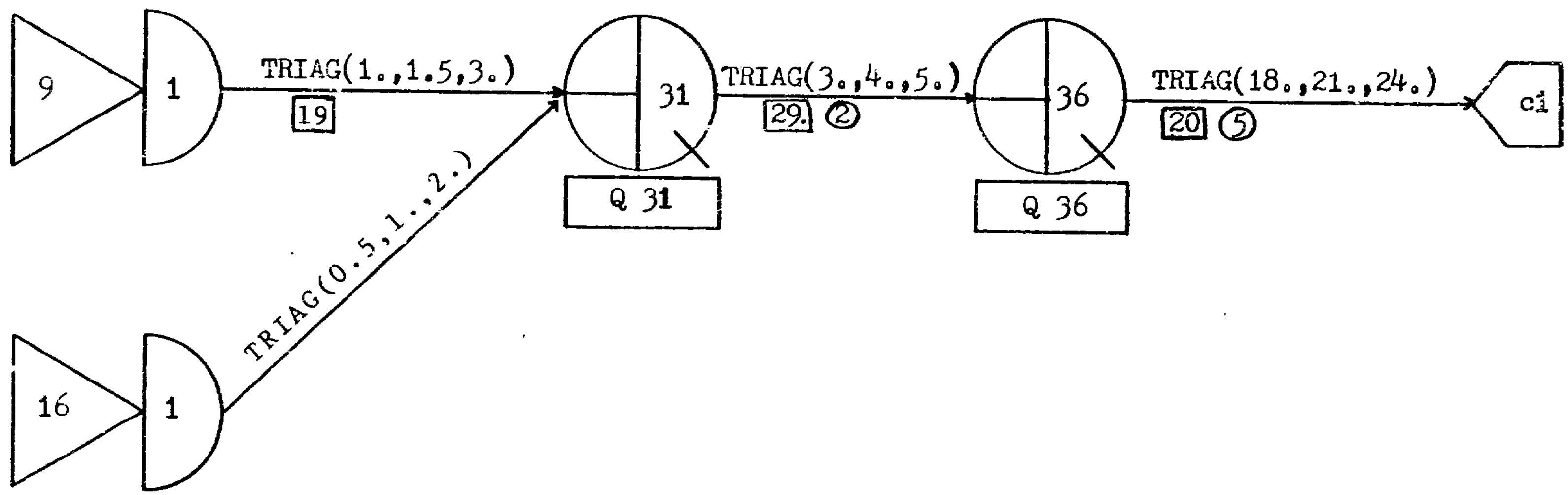


Figure 8.a. Transportation Network, from CCP through sealift POE.

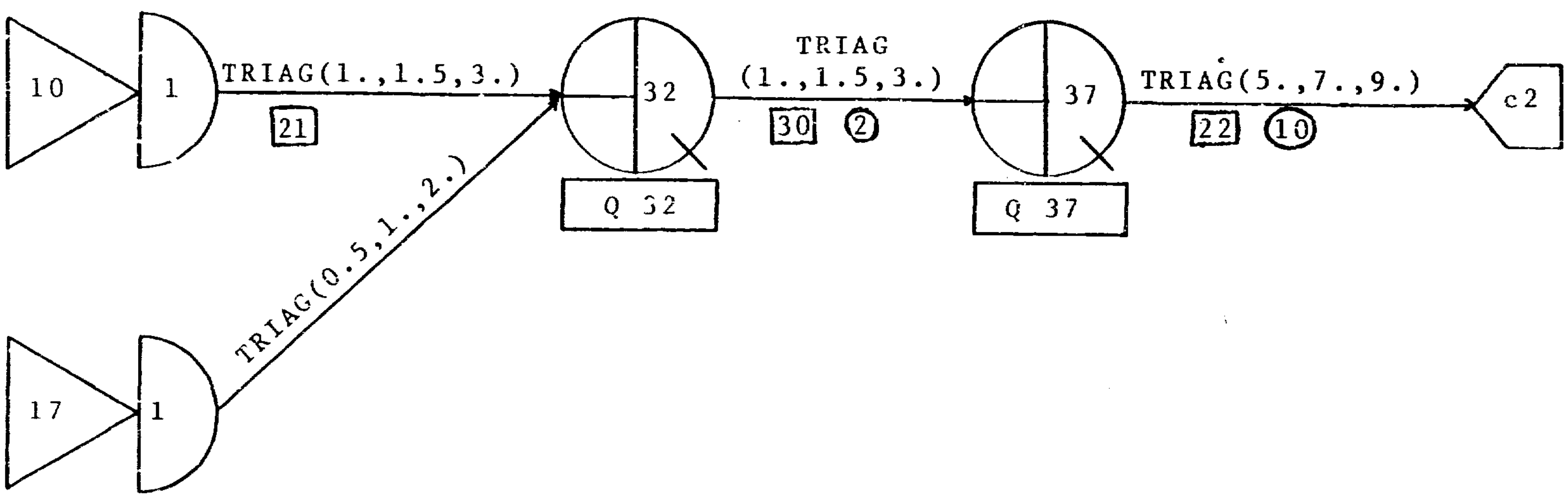


Figure 8.b. Transportation Network, from CCP through airlift POE.

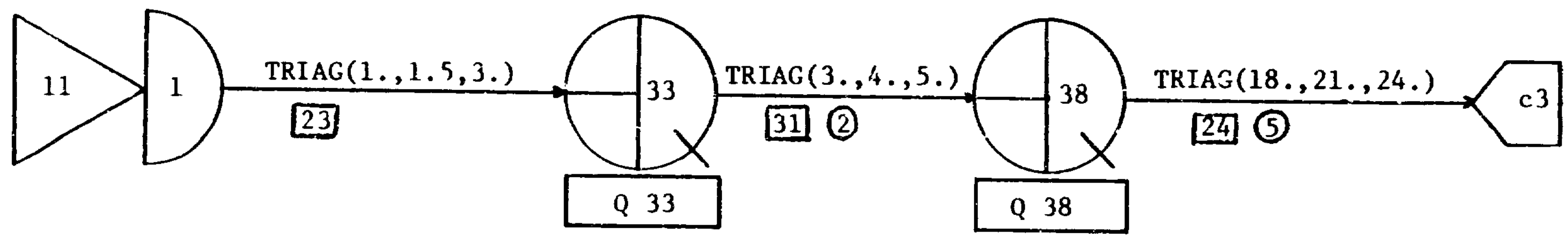


Figure 8.c. Transportation Network, from CCP through #2 sealift POE.

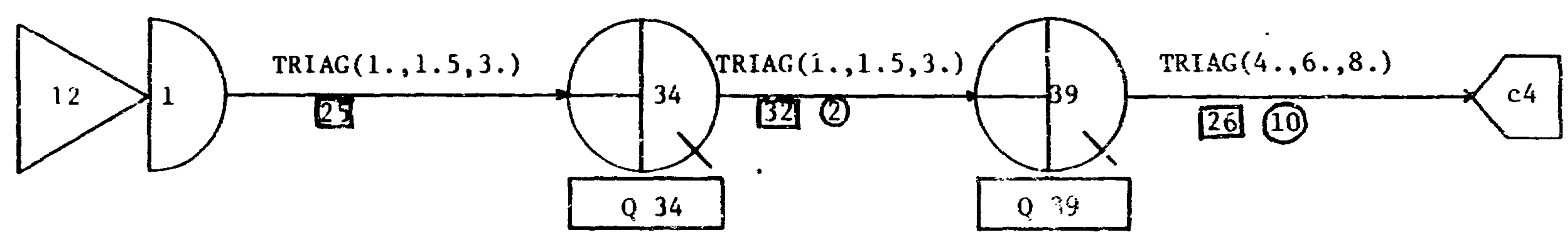


Figure 8.d. Transportation Network, from CCP through #2 airlift POE.

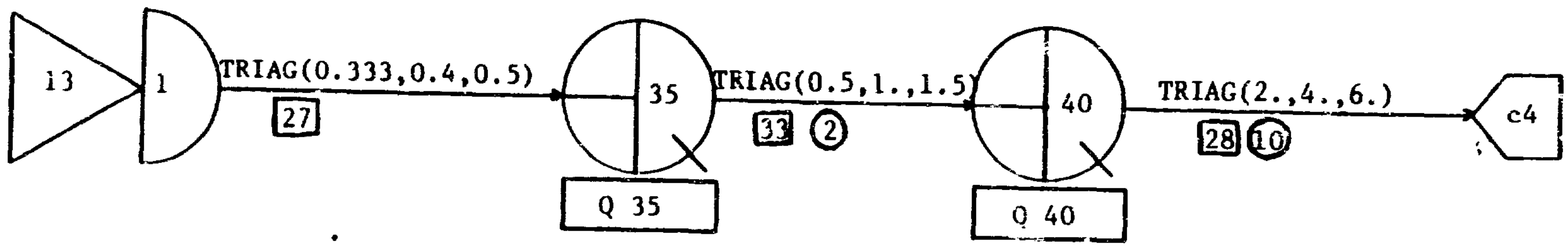


Figure 8.e. Transportation Network, from OCONUS to destination #2.

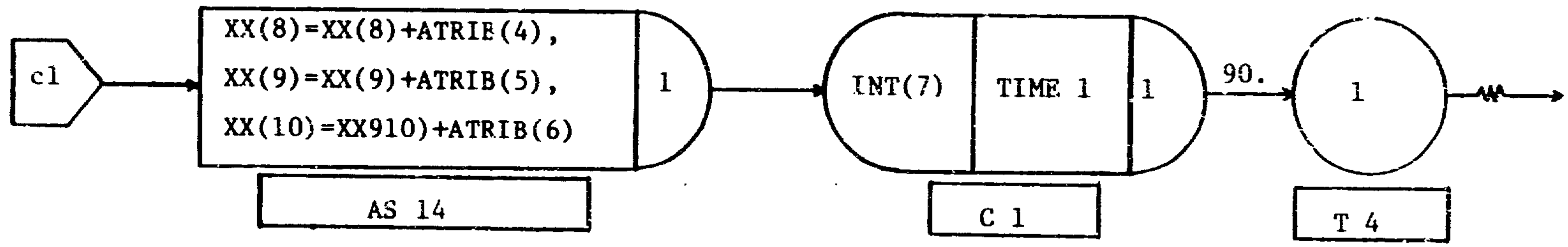


Figure 8.f. Transportation Network, Statistics collection for sealift to destination #1.

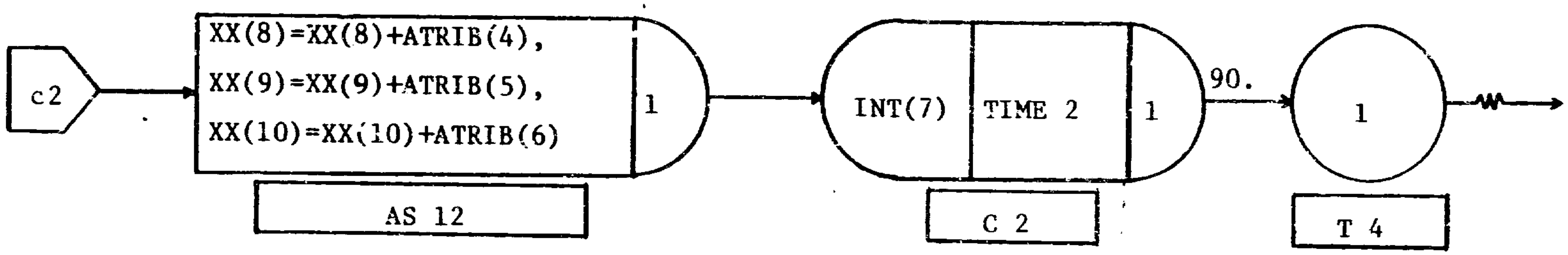


Figure 8.g. Transportation Network, Statistics collection for airlift to destination #1.

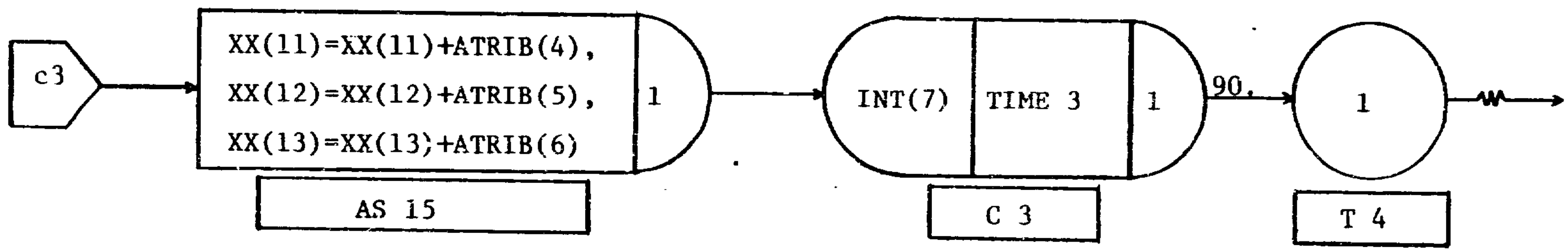


Figure 8.h. Transportation Network, Statistics collection for sealift to destination #2.

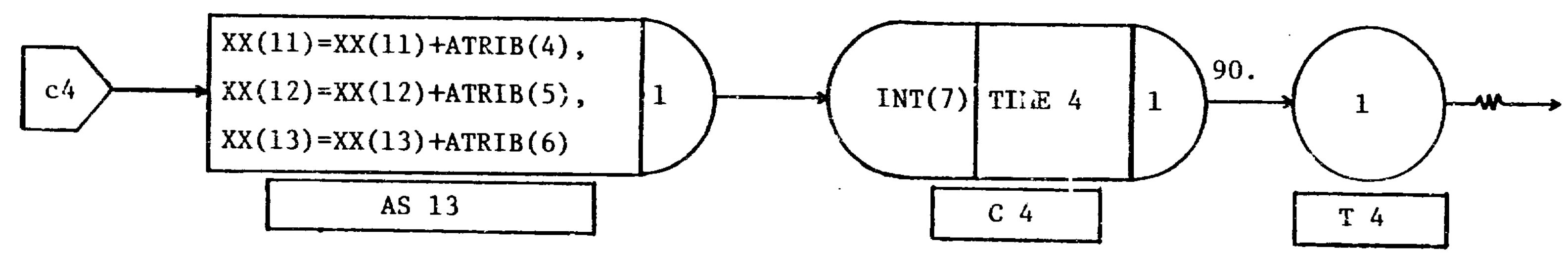


Figure 8.i. Transportation Network, Statistics collection for airlift to destination #2.

cargos delivered, and the time statistics involved.

FORTRAN Inserts

The user written FORTRAN subroutines are designed to simulate discrete events. The thirteen events, used in the simulation model, are of four basic types: (1) generation events, (2) requisition movement events, (3) cargo consolidation events, and (4) a diversion of routed cargo event.

Generation events. As previously mentioned, events 1 and 2 are used to generate the daily requirements for locations 1 and 2, respectively. The quantity of the requisitions is determined stochastically, and each requisition, or entity, is assigned a set of seven attribute values, as follows:

Attribute	Definition
1	Requesting location
2	Combat intensity priority
3	Priority improvement rate
4	CONUS supply utilization code
5	OCONUS supply utilization code
6	Type of supply item
7	Mark time

These entities are then entered into the requisition portion of the CONUS apportionment network.

Events 3 and 4 determine the quantities of CONUS and OCONUS inventory that are available for use on a given day. The quantities are determined by the policies being exercised. Each created entity simulates one supply item, with the attributes of importance being:

Attribute	Definition
1	Supply source code
4	CONUS supply utilization code
5	OCONUS supply utilization code
6	Type of supply item

These entities are then entered into the inventory portions of the CONUS apportionment network and OCONUS apportionment network.

Requisition movement events. Events 5, 6, and 13 are used to move any unfilled requisitions to each possible source. Event 5 moves unfilled requisitions from CONUS-fill to OCONUS-fill networks. Event 6 moves any remaining demands from the OCONUS-fill network to the Recycle/divert network. Event 13 moves unfilled high priority requests to the recycle channels.

Cargo consolidation events. Events 7, 8, 9, 10, and 11 are used to configure pallets into plane and ship loads.

These nodes read the numbers of pallets of critical items processing at each respective point, determine if these amounts are within minimum and maximum standards, and, if so, removes those queued entities and inserts a single entity into the transportation network. The new entity carries different attribute values, assigned as:

Attribute	Value
1	Destination
2	Cargo number (Material Release Order Number)
3	Not used
4	# of Class V items
5	# of Class VII items
6	# of Class IX items
7	Mark time (carried from requisition)

Events 7 and 9 configure shiploads; events 8, 10, and 11 configure planeloads.

Diversion event. In event 12, the diversion event, when the quantity of high priority demands equals the number of items in a palletized load, the search for a pallet load in shipment is initiated. The search is accomplished by an ordered polling of transit processing points, represented by queue nodes. These nodes, all from destination 1, in polling order, are sealift CCP, airlift CCP, sealift POE, and airlift

POE. If a cargo load is available, it is halted, and redirected to the new location. The high priority requisitions are matched as filled. A new set of demands, representing those cancelled by the diversion, are immediately generated and entered into the system. This precludes the needs of the first requesting unit from being lost in the system.

Summary

SLAM enter and event nodes schedule the entry of cargo through the contingency logistic support system. The flexibility of the model is given by event nodes where user-written subroutine model changes of state for the system.

Chapter IV discusses the verification and validation of the simulation model.

IV. Verification and Validation

Introduction

Chapter Four will discuss the evaluation of the simulation model that was constructed for this study. The evaluation of a computer simulation can be divided into three phases. The first phase is verification - insuring that the model behaves as it was intended to behave. The next phase is validation - testing the agreement between the behavior of the model and that of the real system. The final phase is problem analysis - the drawing of statistically significant inferences from the data generated by the computer model (Ref 32:30). Each of these phases will be described in detail.

Verification

Model verification was a continual process, with the model being tested for proper operation after the addition of each event and subroutine. The modular design of the model, as well as the event oriented SLAM simulation language, facilitated this systematic verification process (Ref 19:20).

During the verification phase of the computer simulation, three major aspects of the model were tested. First, the demand generation/fill and the processing/transportation networks were monitored to verify proper operation of the model. Second, the data obtained from statistical distributions were tested for goodness-of-fit. Finally, the model was tested at extreme values of input variables to assure that hypothesized relationships were consistent with the design of the model. Print statements were inserted at appropriate places in the computer model to record the values of attributes and variables of interest. Also, files were printed, and the correct value and order of their contents were verified (Ref 1:233).

Distribution Goodness-of-Fit Tests:

The distributions used in this simulation model were tested for goodness-of-fit by applying the Kolmogorov-Smirnov test. Sample data were obtained from trial simulation runs, and data conformity to the desired distributions was evaluated. The test that was performed failed to reject the accuracy of the assumed distributions. The Max (Abs Diff) for each distribution was obtained from SPSS. A tabulated value greater than the Max (Abs Diff) indicates that the distribution is producing the desired data (Ref 33). The hypothesis tested was that the distribution was Uniform (3,9). The results are shown in Table 2.

TABLE 2

DISTRIBUTION GOODNESS-OF-FIT TEST RESULTS

DISTRIBUTION	SAMPLE SIZE(n)	MAX(Abs Diff)	Tabulated Value (α=.05)
Demands Generated	10	.270	.409

The triangular distribution was selected for processing times and travel times. This distribution was selected because the times normally occurred at the mode of the distribution. The first step was to identify an interval [a,b] in which it was felt the random quantity (process or travel time) would lie with a probability close to 1. The estimates of a and b were obtained from DARCOM experts who were asked for the most optimistic and pessimistic estimates, respectively, of the times indicated (Ref 7). These optimistic and pessimistic estimates were assessed to occur infrequently. The experts were also asked for their subjective estimate of the most likely time to perform the process. This most likely value, m, is the mode of the distribution. Given a, b, and m, (fig 9) the random variable is then considered to have a triangular distribution on the interval [a,b] with mode m (Ref 12:166).

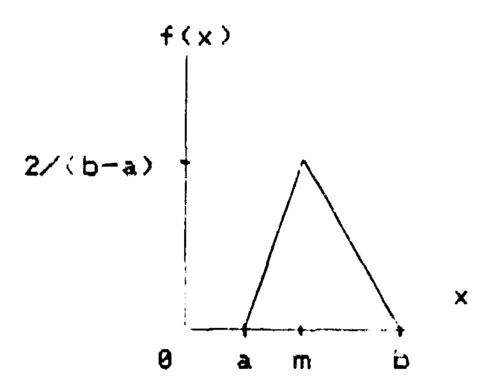


Figure 9 - Triangular Distribution

Model Operation

The proper operation of the model was verified by using the SLAM simulation language's organic trace option to monitor the demand/generation fill and associated processing and transportation sequences. Hand calculations were performed as necessary and compared to computer results.

Model Testing at extremes

During this phase of the verification process, certain variables included in the model were set at levels well beyond those planned for the experiment. All such simulation runs produced results consistent with the behavior hypothesized for the outcomes of system relationships.

Validation

When validating a computer simulation model it is most useful to compare simulated results with the results of a known system. Applying this technique to the contingency support environment is not possible because actual data based on combat experiences is not available. Therefore, for a model of this type other methods of validation must be pursued.

Law and Kelton (Ref 12:338) discuss the following three step approach to validation:

1. Develop the model with high face validity.
2. Test assumptions of the model empirically.
3. Determine how representative the results are.

These are the criteria used to establish the validity of the contingency simulation model. Each step will be discussed.

Face Validity

A model that has high face validity is one which seems reasonable to people who are knowledgeable about the simulated system (Ref 19:13). Face validity was a driving force behind each phase of this model's development. Toward this end, individuals familiar with contingency support and the DTS (Defense Transportation System) were consulted during the design of the model (Ref 40), and all felt the approach and assumptions were logical. The model was initially validated using the QGERT simulation language, then converted to SLAM.

Empirical Testing of Assumptions

The assumptions built into this model were included to simplify the model, while maintaining validity. The experts consulted during model development confirmed that these assumptions were reasonable, given the scope of this research effort (Ref 40).

Simulation Output Data

A modified Turing test was used to validate the simulation output data (Ref 12:341). The object of a Turing test is to find people who are directly involved with the actual system and to ask them to compare the results of the simulation with the outputs from the real system. Since there was no actual contingency data for the SW Asia/Europe system, the Turing test was modified for application to this model.

The DARCOM experts were asked to predict the delivery ratios under various scenarios. The ratios obtained from the experts were then compared to the output data from the simulation model. The predictions agreed favorably with the model output data.

Summary

Now that verification and validation of the model is complete, we can begin testing of the system described by the model. Based on the validation and verification results, the model output should provide an accurate representation of the incorporated flexibility measures for logistical contingency support. This chapter has described the verification and validation of the model, and Chapter V describes the data collection process, measure of merit determination, and the experimental design used.

V. Data Collection and Analysis

Introduction

This chapter reports the results obtained by controlling the priority system, OCONUS supplies, diversion, and fencing. Sixteen policies were evaluated and ten replications were run for each policy. The data was analyzed to make relative comparisons among the policies. Finally, a sensitivity analysis was performed to evaluate the effects of changes in the importance assigned to the response variables.

Measure of Merit

For this thesis, each simulation run begins with a contingency area creating demands (for critical items) upon the supply system. Then, a second contingency area erupts and creates additional demands for scarce resources (critical items). Each run is characterized with specific values assigned to each independent variable, or factor level. With these conditions specified, the delivery effectiveness of the supply/transportation network can be measured by the total number of pallets delivered in total number of days in the system (Ref 24:61-62). This measure of effectiveness accounts for the three types of supplies (Class V, VII, IX) being modeled. They are aggregated in each load by weight and volume criteria. Additionally, this measure of effectiveness is for the contingency area having greater national importance (Area Two in this scenario) and accounts for the last 60 days of the 90 day contingency period. Thus, the measure of merit for the model becomes the ratio of these two measures, or total number of pallets delivered by total number of days to deliver (Ref 40).

Sample Size Determination

After designing and constructing the simulation model, one of the next major considerations is to determine the necessary number of replications to assure that the mean ratio computed for each factor level combination satisfies the desired accuracy requirements. This determination stems from the hypothesis testing that the sample mean is the actual mean.

Ho: μ = sample mean
H1: $\mu \neq$ sample mean

Since hypothesis testing is based on observed sample statistics computed from experimental observations, the decision is subject to possible errors. If the hypothesis is true, but rejected by the sample, a type I error is committed. The probability of a type I error is designated as α. If the hypothesis is accepted, but the alternative hypothesis is true, a type II error is committed. This type of error is designated as β. The determination of sample size should consider both types of error.

The objective of the sample size determination was to attain confidence that the sample mean would be within one-half unit of the true mean. To determine the number of runs, N, required to achieve this level of accuracy, the procedure defined by Shannon (Ref 32:189) was used. The required number of runs is computed using the equation

$$N = \frac{t^2 \quad S^2}{d^2}$$

where t = tabulated t statistic,

S^2 = estimate of variance obtained in the trial experiment, and

d = the half width of the desired confidence interval.

The t statistic, using the procedure described by Hicks (Ref 11:19) for two-tailed tests with α and β considerations, is found by

$$t = t_{\frac{\alpha}{2},df} + t_{\frac{\beta}{2},df}$$

For this experiment, acceptable α and β levels were set as 0.10 and 0.30, respectively.

The determination of S^2 was obtained from a trial experiment of 20 simulation runs, where each factor was maintained at a fixed level. The results of the experiment are shown in Appendix E.

The computations are:

$$\overline{X} = \frac{\Sigma\, Xi}{n} = (36.666)/20 = 1.833$$

$$S^2 = \frac{1}{n-1} \quad \Sigma(Xi - \overline{X})^2 = \frac{1}{19}(0.250) = 0.013$$

$$t_{\frac{\alpha}{2}} = 1.729, \text{ for 19 degrees of freedom.}$$

$$t_{\frac{\beta}{2}} = 1.045, \text{ for 19 degrees of freedom}$$

$$t = 2.774$$

$$t^2 = 7.695$$

$$d = 0.1$$

$$d^2 = 0.01$$

$$N = \frac{(7.695)(0.013)}{(0.01)} = 10.003 \approx 10$$

Based on this result, the simulation should be run 10 times for each factor level combination. This will provide 90% confidence that the sample ratios are within one-half unit of the true ratios (Ref 13:469-479).

To eliminate the possibility of auto-correlation within the output data, the model was designed in such a manner to insure independence of the output data points. Each data point represents the mean delivery ratio achieved over 10 simulation runs. Each of these runs begins with the same parameters and conditions. The random number stream is continuous for the collection of this data point. When the next data point collection process begins, the random number stream is reinitialized and a new set of conditions is established. The same collection process is then repeated for this 10 run sequence. Thus, each data point is not dependent on previously generated data points.

Experimental Design

At the beginning of an experiment, there may be many conceivably important factors. One may suppose that not all of the factors have a significant influence on the results, but usually only a select few actually do. Since the significant factors are not known, it is necessary to screen the full set for the important ones (Ref 11:3-6).

Initially, the seven following factors were investigated:

1. Priority of demands
2. Controlled release of On-hand Inventory, ("fencing")
3. OCONUS Depots
4. Diversion
5. Number of Demands (High or Low)
6. New Acquisition Rate
7. Processing Times

Discussions with DARCOM indicated that the factors of fencing, OCONUS, diversion, and priority were expected to be significant. These four factors were analyzed using a full factorial design. A full factorial design is one in which all levels of a given factor are combined with all levels of every other factor in the experiment. All four of these factors were evaluated at two levels. These two levels indicate whether or not the factor was allowed. Although there are many factors that could influence the contingency support system, we are limiting this analysis to the four factors chosen because of their perceived importance to DARCOM planners. The analysis that will be drawn from these four factors and their interactions is considered sufficient to draw valid inferences about the total system behavior.

The first factor, fencing, is a dichotomus variable that is allowed or not allowed. Level one represents the situation where fencing is allowed and two represents the situation where fencing is not allowed. OCONUS depots were evaluated at two levels. The first level allows OCONUS stocks to be utilized up to a set amount, while level two does not allow the utilization of OCONUS stocks. Diversion was evaluated at two levels. Level one allows the diversion of critical items while enroute and level two does not allow diversion. Finally, the priority factor will be evaluated at two levels. Level one represents a high combat intensity, and level two a low combat intensity.

The full factorial design will be run with every possible combination of the factors and levels. A total of sixteen cells will be analyzed. Using 10 replications of each cell, as shown in sample size determination, a total of 160 simulation runs will be required.

The factor levels for the proposed policies are shown below for the 16 cell sequence:

CELL	PRIORITY	FENCING	OCONUS	DIVERSION
1	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	No
3	Yes	Yes	No	Yes
4	Yes	Yes	No	No
5	Yes	No	Yes	Yes
6	Yes	No	Yes	No
7	Yes	No	No	Yes
8	Yes	No	No	No
9	No	Yes	Yes	Yes
10	No	Yes	Yes	No
11	No	Yes	No	Yes
12	No	Yes	No	No
13	No	No	Yes	Yes
14	No	No	Yes	No
15	No	No	No	Yes
16	No	No	No	No

With this experimental design, the experiment was conducted and data collected. A 4-way ANOVA of the data was made. All of the factor effects and interactions were allowed so they could be evaluated. From this, evaluations of the significance of the main effects are made and the two-way and three-way interactions evaluated.

It was found that allowing or not allowing fencing does not produce any statistically significant changes in the Measure of Effectiveness (MOE).

From this point, a closer look was taken at the main effects of each factor at its various levels. The objective here was to determine which factor level, if any, would result in the highest pallet/time ratio when each factor is considered separately.

Finally, we attempted to identify the optimal combination of factor levels under which to support contingency supply operations for critical items. Each of the 16 cells was considered a separate policy, and the Duncan and Scheffe range comparison tests were conducted at the .05 level to determine which policies gave a higher pallets/time ratio.

Data Analysis

As indicated in the experimental design section, analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) was used to evaluate the four factors. ANOVA tests hypotheses to determine if population means are equal. This allowed us to check if the response variable means were equal based on the different factors and their levels.

Since the tests used rely on the assumptions of independence, homogeneity of variances, and normality, these were investigated first. A discussion of the effects of nonnormality and unequal variances was found in a standard simulation text. It states that the Scheffe multiple comparison procedure "...for small sample populations can still be compared if we take equal sample sizes, n1 = n2 = n. When actually the variances differ, it still gives valid results if we have equal sample sizes, even if these samples are small." (Ref 13:473-474).

Therefore, the results of the standard tests in SPSS were applied. These results indicate that distinctions among the sixteen policies that were tested may be based on certain levels of the experimental factors. The term four-way ANOVA refers to the four factors found significant in the study. A discussion follows of the results of the analysis.

Four-way ANOVA

One four-way ANOVA run was made. This run allowed all of the factor main effects and interactions to be evaluated. This indicated that three of the four main effects (Priority, OCONUS, Diversion) were significant, using an alpha level of 0.05. One main effect, fencing, was found to be statistically insignificant. Additionally, two two-way interactions and one three-way interaction were found to be significant. These effects and interactions will be discussed next.

Main Effects

The only main effect found to be statistically insignificant was fencing. This result was not totally unexpected. In this model, the first contingency area runs for 30 days before the second contingency erupts. If a demand has a high enough priority from the first contingency area but has not been filled when the second area begins, it's priority improvement factor will cause it to be filled before many demands from the second area (which has a higher combat intensity) are filled. This is due to the single priority system that overlaps for both areas.

The main effects are depicted graphically in Figure 10. When interpreting this figure and all following figures in this chapter, only the end points of each straight line are measured data. These end points are the ratio of pallets/day for that particular factor level. The straight lines connecting the end points have no significance other than to

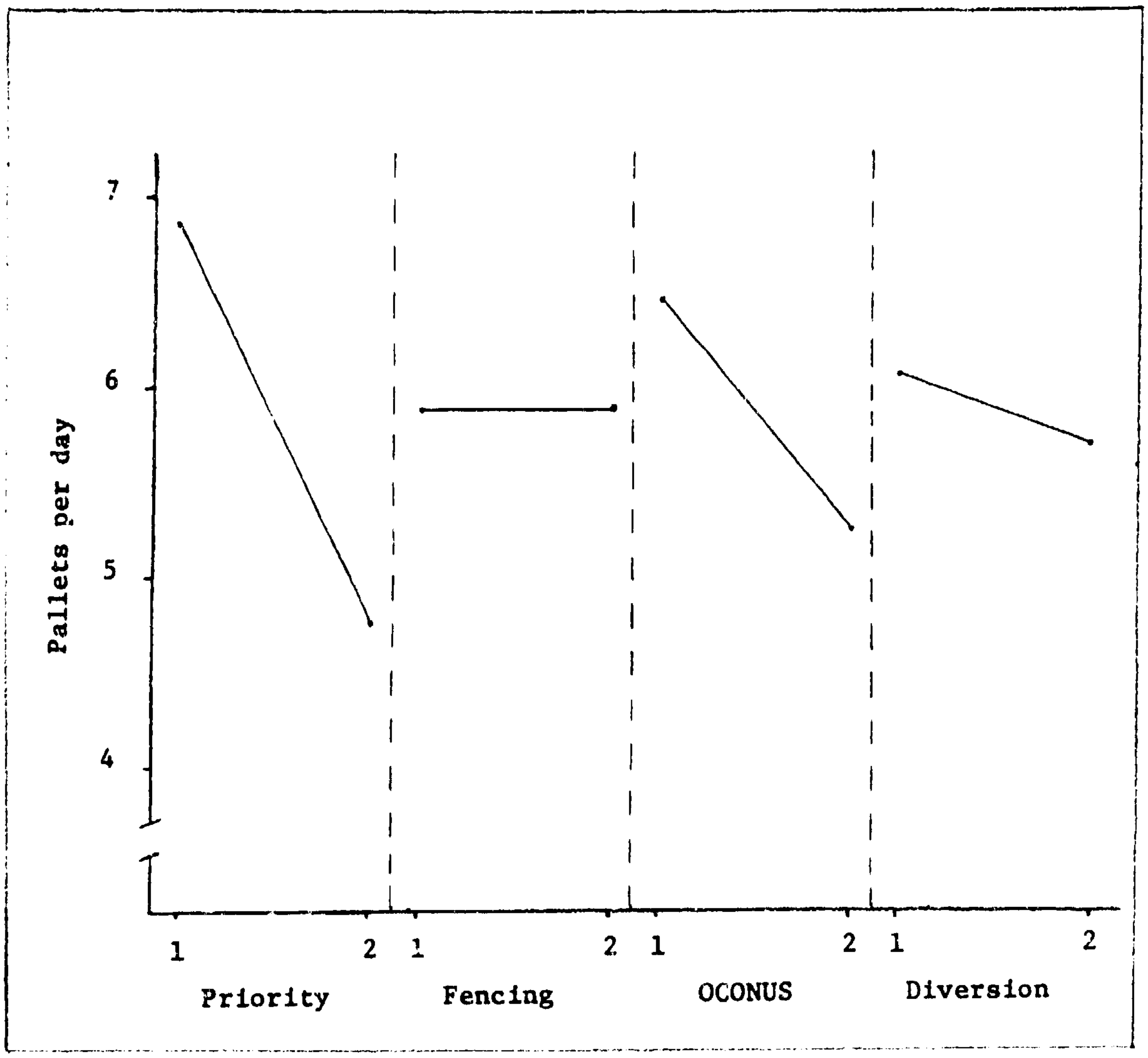


Figure 10 - Influence of Main Effects

illustrate the change in the pallets/day ratio between factor levels. This does not imply a linear relationship as no attempt to evaluate the intermediate factor levels was made.

All of the main effects behaved as expected. The priority system effect had its highest impact when a specified priority assignment system was used, and decreased significantly when no system was used. Fencing was found to be insignificant for the reasons stated earlier, and it's graph was found to have almost no slope, which indicated little effect. OCONUS had the next largest effect. This is reasonable as previously unavailable supplies are now available, in limited quantities, to fill demands in areas geographically closer, in most cases, to the requesting contingency. Finally, diversion was a significant effect in that it allowed supplies that were either enroute to, or intended for, another contingency area to be rerouted to an area of higher combat intensity. The next section will discuss the two-way interactions between these factors.

Two-way Interactions

The following two-way interactions were found to be significant:

1. Priority and diversion
2. OCONUS vs. diversion

The interaction between priority and diversion is shown in Figure 11. This graph portrays the results on the measure of effectiveness when each policy was permitted, then not permitted, in the experiment. This is indicated by the scale 1 to 2 on the bottom axis. The paired graph lines reflect the measure of effectiveness when the interacting factor is permitted or not permitted in the experiment. For example, as the priority policy ranges from 1 to 2, the top line depicts the experimental results when diversion was permitted and the bottom line depicts the results when diversion was not permitted. The skewness in the lines, showing a greater difference in MOE when priority was not permitted than when permitted, across the similar test conditions of the diversion policy, indicates the interactive, or synergistic effect of the factors. If there were no interactions, the lines would be parallel.

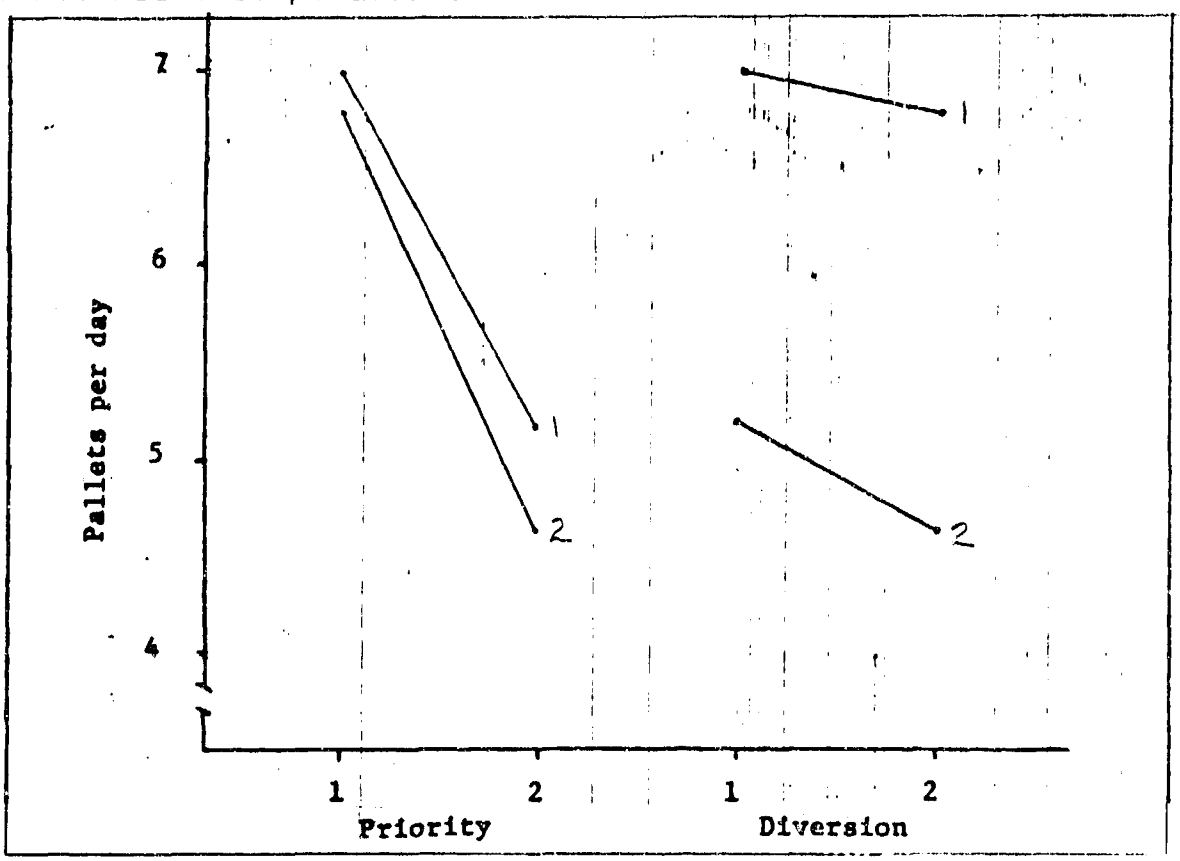


Figure 11 - Interaction of Priority and Diversion

The interaction between OCONUS and diversion is shown in Figure 12. The interactive effect here is more pronounced than the priority - diversion interaction. This is due to the fact that there is little change in the MOE as diversion ranges from 1 to 2 when OCONUS is permitted, and a large change when OCONUS is not permitted. Recalling that (1) diversion is keyed by an accumulation of a pre-determined number of high priority requests, and (2) OCONUS supplies are made available on a per day basis, it can be seen that when OCONUS is allowed, the high priority requests, being at the top of the queue, are filled, and do not accumulate rapidly enough to cause cargo diversion. When OCONUS is not allowed, the high priority requests accumulate, and diversion has statistical significance. This interaction portrays a competition effect, as the two alternative supply points, diversion and OCONUS, compete to fill high priority requisitions.

For both two-way interactions, the lines depicting the interacting factor's presence dominated those depicting its absence, and this corresponds with the results shown in the main effects analysis.

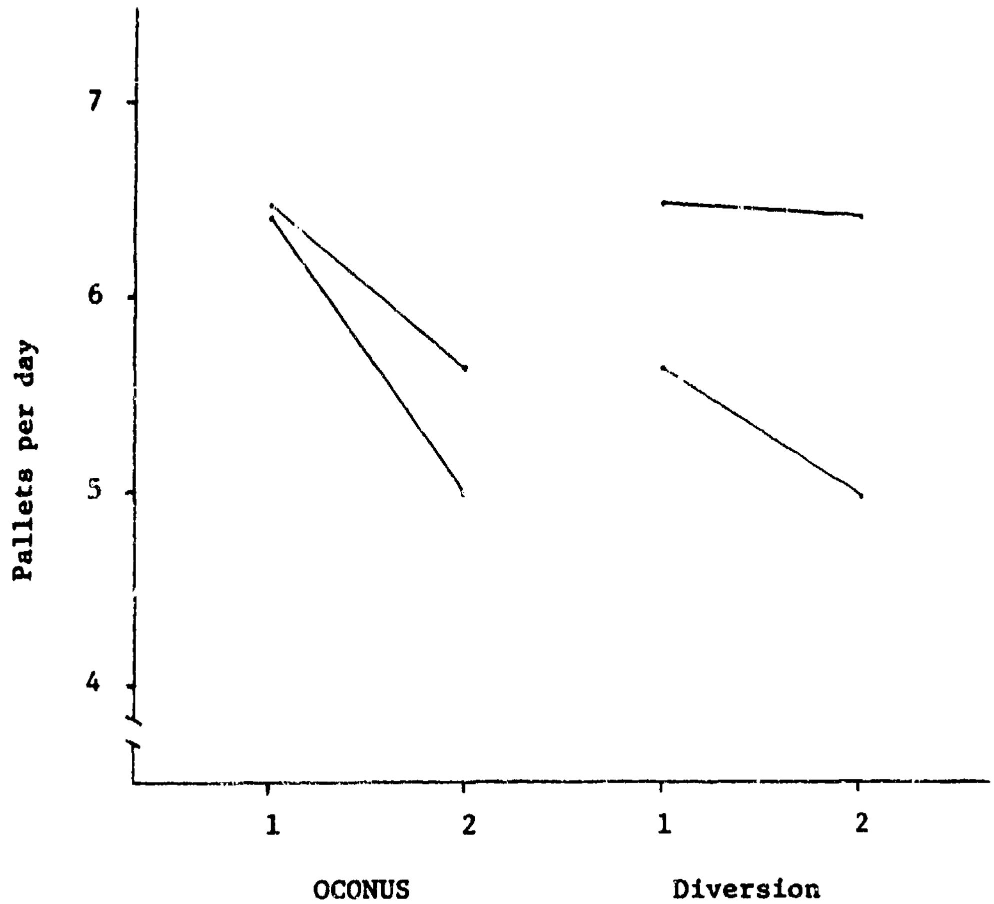


Figure 12 - Interaction of OCONUS and Diversion

Three-way Interactions

One three-way interaction of priority - OCONUS - diversion was found to be significant. The highest pallets/day ratio was observed when all three factors were utilized. This interaction was anticipated as diversion is dependent upon priority, and, as previously discussed, diversion and OCONUS compete to fill high priority requests. These results are consistent and logical when looking at the analysis of the main effects, and two-way interactions.

ONEWAY ANOVA of Policies

The next phase of the data analysis was to look at the main effects of each factor at its two levels. The objective was to determine which level, if any, resulted in the highest pallets/day ratio when each factor was considered separately. A one-way multiple comparison could have been run to select the best level; however, by observing the graphs in Figure 10, it was shown that by setting each factor at it's highest level (1), the highest pallets/day ratio would result. The final phase, then, was to attempt to identify the optimal combinations of factor levels to support multiple contingency operations. Each of the 16 factor level combinations was designated a separate support policy. Each of these 16 policies is directly related to the 16 cells in the four-way ANOVA. A one-way ANOVA of pallets-per-day ratio vs. policy was run for these 16 policies. The F-ratio between groups was 302.5 which indicates that a significant differences does exist between some of the policies. The Scheffe and Duncan multiple range comparison tests were conducted at the 0.05 level to determine which policies offered the higher pallets-per-day ratios.

The Scheffe and Duncan methods identified four policies - policies 5, 6, 1, 2 - that were significantly better than all the other policies. Policies 3 and 7 were slightly less significant than the policies in the first subset. The other subsets below these contained numerous policies and will not be discussed.

Policy 5 achieved the highest pallets/day ratio at 7.4. This suggests that one of the most effective means of contingency support is to allow OCONUS supplies to be available to other geographic regions and to have a priority system which will allow units with a greater combat intensity to have their demands filled first. Policies 6, 1, 2 were also in the same subset, which indicates they were statistically indistinguishable from Policy 5. The only real differences between these policies, since fencing was found to be insignificant, is whether or not diversion is allowed. Policies 5 and 6 and Policies 1 and 2 are paired with regard to diversion, and the policy with the higher ratio also allows diversion.

Policies 3 and 7 were in the next subset examined. These policies indicated that if OCONUS supply sites were not allowed for contingency support, then a diversion plan would help to increase the pallets-per-day ratio.

Table 3 summarizes the analysis of these six policies.

Table 3

SUMMARY OF ONE-WAY ANOVA OF POLICIES

POLICY	PRIORITY	FENCING	OCONUS	DIVERSION	RATIO
5	YES	NO	YES	YES	7.43
2	YES	YES	YES	NO	7.42
6	YES	NO	YES	NO	7.41
1	YES	YES	YES	YES	7.36
3	YES	YES	NO	YES	6.56
7	YES	NO	NO	YES	6.52

Sensitivity Analysis

Several assumptions were made in this model that require more in-depth analysis to determine the model's sensitivity to variations in the values of parameters used with assumptions. The assumptions that were examined more closely are:

1. Priority policy
2. OCONUS policy
3. Diversion policy
4. Fencing policy
5. Model parameters
6. Scenario variation

Priority Policy

The utilization of a priority policy had the most significant main effect of the four policies. It was an element of one of the significant two-way interactions and also of the three-way interactions. The priority value is determined by an initial setting and a priority improvement rate. For the experimental runs, the area two demands had a higher initial value setting and a faster improvement rate than area one demands.

In the sensitivity runs, where the initial value setting was increased and the improvement rates were equal to ten percent higher for area two, no significant difference was noted over those of the original data runs. However, when the improvement rate for area one was greater than are two (1.1 to 1.01), there was a drop in the number of cargos delivered to area two (see Appendix F.1). The drop was not significant (see Appendix F.2), but it revealed a trend. Further examination reflected that when the difference in improvement rate ratio was 1.01: 1.2 and greater, the demands of the location with the higher rate began to clearly dominate those of the other location. Greater separation in initial value selection ranges required longer time periods for dominance to appear. If the two contingency locations are of equal national importance and each is to receive a portion of the inventory, then the respective improvement rates should be in the 1.01 to 1.05 range. If one is much more important, then the mix of 1.01 to 1.1 is best, and if one is to be nearly neglected then 1.01 to 1.2 can be used.

Additionally, the significance of the priority - diversion interaction is affected by the value setting of location two's improvement rate. A higher improvement rate creates more high priority demands, which triggers more diversions, and lower improvement rates create fewer diversion. However, if the improvement rate is too great, then the deliveries initially routed to area one follow a round-about delivery path to area two, so caution must be exercised in the assignment of improvement values.

The priority policy is tied to the concept of highest valued demands get first fill. Sensitivity runs, for all cells, with the demand queues serving on a first-come-first-serve basis greatly negates the power of the priority policy. Under this scenario, use of OCONUS stock becomes the dominant policy, and the impact of the priority-diversion system becomes insignificant. Therefore, the priority policy must have the highest-value-first (HVF) framework to operate in to be fully utilized. (See Appendix F.3. and F.4.)

OCONUS Policy

The availability of OCONUS inventories for global use was the second most significant main effect. The data collection was made from runs that had a total available OCONUS quantity that was 10 percent of the total CONUS quantity. These OCONUS quantities were released at a rate of ten percent (of remaining amount) per day. Data analysis required that both the amount and release rate be examined.

The release rate was examined first. The rate was varied from 5 to 100 percent per day, with the end results having no significant differences. (See Apendix F.5. and Appendix F.6.) Since the model structure only permits OCONUS stocks to be used at location two, and the number of total demands exceeds the total resources, all OCONUS stocks used get to location two before the expiration of the time period of interest. However, a comparative examination of the histograms shows that the greater the availability rate, the faster these supplies get to the second area (See Figure 13). Thus, if time lapse is important, then the release rate should be greater.

The amount of OCONUS available inventory was found to be proportional to its impact on the system. By increasing the total available amount to 14 percent of the total CONUS inventory, this policy becomes as powerful as the priority policy (both policies evaluated as sole strategies for this analysis; see Appendix F.7.), the most powerful main effect.

Examination of the OCONUS-diversion and the OCONUS-diversion-priority interactions revealed that these interactions were the results of "competition" to fill high priority demands. An increase in the number of OCONUS filled demands reduced the number requiring fill-by-diversion. The converse is also true. Because the diversion system is amplified by the priority policy, both are similarly reflected with OCONUS in the 3-way interaction.

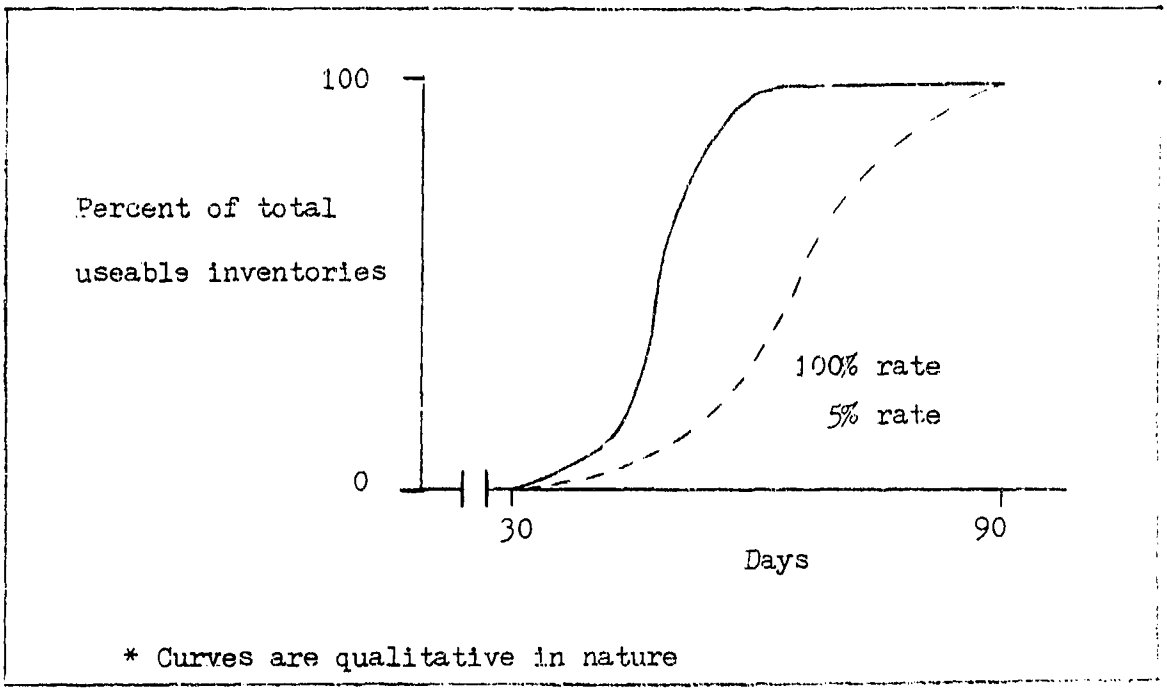


Figure 13 Availability Rate

<u>Diversion Policy</u>

The diversion policy is significant as a main effect, and it also appears in all significant interactions. A cargo diversion, in this simulation framework, requires a set number of high priority demands to accumulate before initiation. Further, any high priority demands filled by diversion will no longer compete for OCONUS stocks, hence, the interactive effects. Since the diversion policy is keyed by the magnitude of the priority system, any changes that would increase the number of high priority demands will also serve to increase the number of cargo diversions.

An examination was made of the diversion locations (airlift and sealift CCP's and POE's), and it was determined that the cargos were diverted from the airlift and sealift CCP's. The reason no diversions come from the POE's was due to the assumption that all shipments were fully supportable by the DOD transportation system. In the data collection run, all cargos received at the POE processed immediately onto an aircraft. This precluded a cargo from being "caught" and diverted. Using a more realistic approach that the cargos would be forced to queue for airlift and sealift, further simulation runs were conducted. In the first (OCONUS assets were also permitted) there was no significant difference between the runs where cargos arrived and immediately departed the POE's and those where cargos arrived and waited at the POE's. Investigation revealed that in these situations, the high priority demands got filled by OCONUS supplies before sufficient demands accumulated that would require diversion from the POE's. However, in the simulation runs where OCONUS supplies were not allowed, there was a significant difference. (See Appendix F.8.) The scenario that required cargos to arrive and wait for airlift or sealift had a 12% increase in MOE over the scenario where cargos processed immediately through.

Fencing Policy

The analysis determined that the controlled release of stocks, or "fencing", policy was insignificant. Analysis of the simulation model revealed that its insignificance was attributable to the newly released inventories having unspecified usage codes. In the priority fill framework, the demands from location one, prior to eruption of the second contingency, were assigned the same initial values as those from location two after eruption. Unfilled location one demands, because of the priority improvement rate, always ranked higher in the queues than location two's new demands. So, when inventories were released, they went to location one first. Use of this type of policy fairs no better in a first-come-first-serve framework as location one's unfilled demands are already in the queue when location two's arrive. Test runs were also made with "fenced" amounts increased, but these did not reflect any significant change. To make fencing significant, the priority system would have to assign initial values, to location two demands, in a range that was always higher than location one, and allow only a minimal improvement rate. However, this structure tends to "cut-off" the first area from nearly all supplies, which is contrary to the initial intent. Therefore, a controlled release policy, where cargos have general usage, is undesirable.

Use of a controlled release policy structured as in the OCONUS system (stocks set aside for use by a specific contingency) would have significant effect on the MOE, but would proportionally reduce the amount of inventory available for general use (the amount deliverable to location 1).

Model Parameters

The following model parameters were analyzed for their relative impacts on the system:

1. demand rate
2. processing times

3. new acquisition rates

4. initial inventory levels

The simulation was exercised with the demand rates from both areas being the same. Examination of runs made with the rates increased and decreased caused the values of the MOE to be varied, but they did not cause any changes in the trends between cells of the model; the dominant policies remained the same.

Variation of the processing times caused the pallet histograms to shift along the time axis, but the magnitude of the increases did not change, and once all inventories were depleted, the relative MOE's between cells is not changed.

Increasing the new acquisition rate, while increasing the final MOE's, also created across-the-board increases, and did not affect the differences between cells. This was due to the new acquisitions having unspecified utilization codes. Likewise, the effect of changes in the initial inventory level was not significant as it did not create changes in the trends between cells.

Scenario Variation

Although only one scenario was investigated during this study, the model is capable of evaluating various scenario combinations. Minor changes in the transportation network times and the polling sequence for OCONUS supplies will allow the model to evaluate these different scenarios, and should not change the overall operation of the model. Even with a scenario of a third contingency, the results drawn from this study should remain consistent.

Summary

The results obtained from the data analysis have been discussed in this chapter. These results may be used to determine the optimal policy or strategy for Army contingency logistical support for a given scenario and conditions. The mean square error (MSE) of the four-way ANOVA was evaluated to find the statistical model for selected conditions and scenarios. The four-way ANOVA statistical model was used for the conditions tested in this research. Appendix D contains SPSS results.

Chapter VI will discuss the conclusions and recommendations that evolved from this study.

VI. Conclusions and Recommendations

Conclusions

This research project was undertaken to conceptualize and test allocation and apportionment policies that would enhance the flexibility of the U.S. Army logistics system in times of multiple contingency situations. The specific issues developed were: (1) a priority system which allowed maximum flow to the contingency having greater national interest without completely cutting off the second contingency area, (2) a limited global utilization of OCONUS supplies, (3) a diversion policy for items that had not left the POE, and (4) finally, the controlled release of critical items determined by total inventory level. The general conclusion of the authors is that a useful methodology and model has been developed in this project, and the methodology indicates that certain policies can offer improvement over procedures currently in use.

Of the four concepts developed, three were found to offer significant improvement over the current systems. These three are:

1. Allocation of critical items based on a combat intensity priority system.
2. Allocation of all critical items, both CONUS and OCONUS inventories, on a pre-determined global scale.
3. Re-apportionment of enroute shipments.

Utilization of these policies individually or in particular combinations will offer varying degrees of improvement. The fourth concept developed, the controlled release of critical items determined by total inventory level, did not produce a significant improvement over the current system.

The robustness of the policies and their combinations is due to the operational environment. The OCONUS policy and its combinations offer the greatest improvement if requisitions are filled on a first-come-first-serve basis. The priority policy and its combinations offer the greatest improvement if requisitions are judged on their relative importance, highest-value-first. The highest-value-first system offers improvement over the first-come-first-serve system, which most closely replicates the current logistical system.

For this study, the highest-value-first environment was the case of greatest interest. Under these conditions, the combination of priority policy, OCONUS policy, and divert policy had the greatest impact. Further, the combination of priority policy with OCONUS policy, and the combination of priority policy with divert policy, were found to carry greater impact than any of the policies employed on an individual basis. In descending order, the priority policy offered more than the OCONUS policy, which is preferred to the diversion policy. It must be noted that each of these policies has sensitivities. The priority policy requires the highest-value-first environment. The OCONUS policies rankings were based on its available inventories being ten percent of CONUS available inventories, and making more stocks available increases its contributions. The diversion policy is sensitive to changes in the priority policy.

The controlled release of critical items, as determined by total inventory levels, does not offer improvement to the present system, if its releases are for general usage. However, if the controlled release was then allocated to a specific polling of geographic regions, its concept would be identical to the OCONUS policy and would offer a significant impact, but, this would eliminate that specified stockage amount from the general usage inventory.

In a more general sense, the conclusions to be drawn from this project are: (1) An allocation system that judges the relative importance of competing units contingency requisitions is preferred to the current first-come-first-serve system, (2) the priority, OCONUS, and diversion policies offer improvement over the current system, and (3) the computer simulation model developed to compare these policies was adequate for projection of qualitative trends.

Recommendations

The following recommendations are submitted as a result of this research:

1. A feasibility study be undertaken to determine how readily the policies tested can be adapted for actual use. This should include: (1) a revision of the current

priority system or the development of a new system that can distinguish different contingency operations, (2) an evaluation of the Logistics Intelligence File to insure that it has real-time requisition and shipment tracking capability, (3) an analysis of contingency area projected supply requirements to determine the amounts of OCONUS stocks that are available for global utilization, and (4) an analysis of various competing contingency scenarios to determine comparative issue ratios for the competing areas.

2. Expansion of this research to provide more detailed modeling of Military Airlift Command force assets, the Civil Reserve Aircraft Fleet, (CRAF) and the processing capabilities at Consolidation and Containerization Points and Points of Embarkation to more accurately reflect the responses of the transportation system for supplies that have been allocated.

3. Expansion of this research to evaluate cargo movement capacities per transportation path, by shipment carrier and destination, to provide day-by-day tracking of each pallet or planeload/shipload to determine the areas and means necessary to expedite processing and delivery.

4. Expansion of this research to evaluate more than two concurrent contingency operations, with a range of relative values between the operations to replicate differences in size and level of national importance of

the various operations.

5. Lastly, multiple criteria decision theory should be applied to OCONUS prepositioned materials to determine the military gains and political costs of inter-theater movement of these materials. This should include a detailed examination of the types and amounts of critical supply items by theater.

Further Research

This research effort shows that there are alternatives that can be developed to enhance flexibility in the U.S. Army logistics systems. However, the demonstrated trends are qualitative, and the policies should be further modeled into more detailed simulations of the logistics system to attain more accurate quantitative measures, and, from that point, be evaluated for incorporation into the system.

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APPENDIX A

SLAM DESCRIPTION

USER CALLED SUBROUTINES

Appendix A

Network Input Statement Descriptions

ACCUMULATE node description summary.

Node Type: ACCUMULATE

Symbol: 

Function: The ACCUMULATE node is used to combine entities. The combining of entities is controlled by the specification of the release mechanism consisting of the number of arrivals required for the first release (FR), the number of arrivals required for subsequent releases (SR), and the attribute holding criterion for entities to be routed (SAVE). A maximum of M emanating activities are initiated. As entities arrive to an ACCUMULATE node, the number of required arrivals is decremented. When the required number have arrived, an entity is released from the node. The attributes of the released entity are assigned according to the SAVE criterion.

Input Format: ACCUMULATE,FR,SR,SAVE,M;

Specifications:

Input Field	Options	Default
FR	positive integer or ATRIB(NATR)	1
SR	positive integer or ATRIB(NATR)	1
SAVE	Save criterion specified as: FIRST-Save the attributes of the first arrival in a batch. LAST-Save the attributes of the last arrival in a batch. LOW(NATR)-Save the attributes of the entity having the lowest value of ATRIB(NATR). HIGH(NATR)-Save the attributes of the entity having the highest value of ATRIB(NATR).	LAST

	SUM-Each attribute of the released entity equals the sum of that attribute for all entities in the batch. MULT-Each attribute of the released entity equals the product of that attribute for all entities in the batch.	
M	positive integer	∞

Activity Node Description Summary

Node Type: ACTIVITY (Regular)   Symbol: DUR,PROBorCOND
$\boxed{A}$

Function: A REGULAR activity is any activity emanating from a node other than a QUEUE or SELECT node. The REGULAR activity is used to delay entitis, perform conditional/probabilistic testing, and to route entities to non-sequential nodes. If the activity is numbered, statistics are provided on the activity utilization, and the number of active entities and the total entity count are maintained as the SLAM variables NNACT(A) and NNCNT(A), respectively.

Input Format:

ACTIVITY/A,duration,PROB or COND,NLBL;
Specifications:

Input Field	Options	Default
A	positive integer between 1 and 100 or ATRIB(I)=J,K	no statistics
duration	constant, SLAM variable, SLAM random variable, REL(NLBL) or STOPA(NTC)	0.
PROB or COND	probability: constant, SLAM variable or SLAM random variable. Must be between 0 and 1 condition: value.OPERATOR.value where value is a constant, SLAM variable, or SLAM random variable and OPERATOR is LT, LE, EQ, GE, GT, or NE. Two or more conditions can be specified that are separated by .AND. or .OR.	always take activity
NLBL	the label of a labeled node which is the end node of the activity	next sequential node

Node Type: ACTIVITY (Services) Symbol: DUR,PROB (N) [A]

Function: A SERVICE activity is any activity emanating from a QUEUE or SELECT node. The service activity is used in conjunction with the QUEUE node to model a single server queue or a queue with N identical servers. The service activity is used in conjunction with the SELECT node to model multiple channel queues with non-identical servers. Statistics are collected on all service activities. If the activity is numbered, the server status (number of busy or blocked servers) and total entity count are maintained as SLAM variables NNACT(A) and NNCNT(A), respectively.

Input Format: ACTIVITY(N)/A,duration,PROB,NLBL;

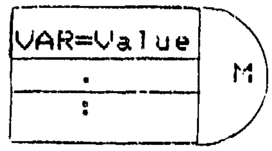
Specifications:

Input Field	Options	Default
N	positive integer	1
A	positive integer between 1 and 100 or ATRIB(I)=J,K	none
duration	constant, SLAM variable, SLAM random variable, REL(NLBL) or STOPA(NTC)	0.
probability	constant, SLAM variable, or SLAM random variable. Must be between 0 and 1. Used only to represent identical servers emanating from a QUEUE node as a set of probabilistic service activities. Each activity will have the number of servers specified on the first activity defined.	1
NLBL	label of a labeled node	sequential node

ASSIGN node description summary.

Node Type: ASSIGN

Symbol:



Function: The ASSIGN node is used to assign values to SLAM variables (VAR) at each arrival of an entity to the node. A maximum of M emanating activities are initiated.

Input Format: ASSIGN,VAR:value,VAR=value,...,M;

Specifications:

<u>Input Field</u>	<u>Options</u>	<u>Default</u>
VAR	ATRIB(INDEX),SS(INDEX),DD(INDEX), XX(INDEX), or II, where INDEX is a positive integer or the SLAM variable II.	error
value	An arithmetic expression containing constants, SLAM variables, or SLAM random variables. Up to 10 addition, subtraction, multiplication and division operations may be performed in an expression. Multiplication and division will be performed before addition and subtraction. Parentheses are allowed only to denote subscripts.	error
M	positive integer	∞

COLCT node description summary.

Node Type: COLCT

Symbol: (TYPE | ID,H | M)

Function: The COLCT node is used to collect statistics that are related to: either the time an entity arrives at the node (TYPE); or on a VARIABLE at the entity arrival time. ID is an identifier for output purposes and H is a histogram specification for the number of cells (NCEL), the upper limit of the first cell, (HLOW) and the cell width (HWID). A maximum of M emanating activities are initiated.

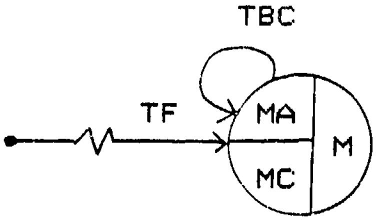
Input Format: COLCT(N),TYPE or VARIABLE,ID,NCEL/HLOW/HWID,M;

Input Field	Options	Default
N	positive integer	next sequential index
TYPE	FIRST - records the time of the first arrival to the node. At most one value is recorded per run. ALL - records the time of all arrivals. BETWEEN - uses the time of the first arrival as a reference point. On subsequent arrivals, records the time between arrivals. INT(NATR) - records the time interval between the time of arrival and the time stored in attribute NATR of the arriving entity.	none
or		
VARIABLE	Records the value of a SLAM variable: ATRIB(I), XX(I), SS(I), DD(I), NNQ(I), NNRSC(I), NNACT(I), NNCNT(I), NNGAT(I), TNOW, or II.	
ID	maximum of 16 characters beginning with an alphabetic character	blanks
NCEL	positive integer	no

		histogram
HLOW	constant	0.0
HWID	positive constant	1.0
M	positive integer	∞

CREATE node description summary.

Node Type: CREATE Symbol:



Function: The CREATE node is used to generate entities within the network. The node is released initially at time TF and thereafter according to the specified time between creations TBC up to a maximum of MC releases. At each release, a maximum of M emanating activities are initiated. The time of creation is stored in ATRIB(MA) of the created entity.

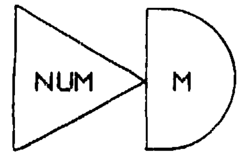
Input Format: CREATE,TBC,TF,MA,MC,M;

Specifications:

Input Field	Options	Default
TBC	constant, SLAM variable, or SLAM random variable	∞
TF	constant	0.
MA	positive integer	no marking
MC	positive integer	∞
M	positive integer	∞

ENTER node description summary.

Node Type: ENTER Symbol:



Function: The ENTER node is provided to permit the user to enter an entity into the network from a user-written event routine. The node is released at each entity arrival and at each user call to subroutine ENTER(NUM). A maximum of M emanating activities are initiated at each release.

Input Format: ENTER,NUM,M:

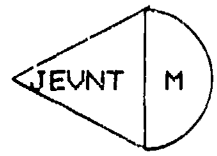
Specifications:

Input Field	Options	Default
NUM	positive integer	error
M	positive integer	∞

EVENT node description summary.

Node Type: EVENT

Symbol



Function: The EVENT node causes subroutine EVENT to be called with event code JEVNT at each entity arrival. This allows the user to model functions for which a standard node is not provided. A maximum of M emanating activities are initiated.

Input Format: EVENT,JEVNT,M:

Specifications:

Input Field	Options	Default
JEVNT	positive integer	error
M	positive integer	∞

GOON node description summary.

Node Type: GOON   Symbol: M

Function: The GOON node provides a continuation node where every entering entity passes directly through the node. It is a special case of the ACCUMULATE node with FR and SR set equal to one. A maximum of M emanating activities are initiated.

Input Format: GOON,M:

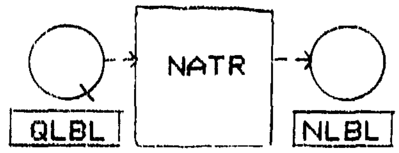
Specifications:

Input Field	Options	Default
M	positive integer	∞

MATCH node description summary.

Node Type: MATCH

Symbol:



Function: The MATCH node is used to delay the movement of entities by keeping them in QUEUE nodes (QLBLs) until entities with the same value of attribute NATR are resident in every QUEUE node preceding the MATCH node. When a match occurs, each entity is routed to a route node NLBL that corresponds to QLBL.

Input Format: MATCH,NATR,QLBL/NLBL,QLBL/NLBL,...;

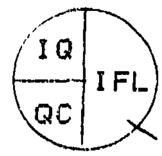
Specifications:

Input Field	Options	Default
NATR	positive integer	error
QLBL	a QUEUE node label	error if less than 2 QLBLs specified
NLBL	a node label for any type of node	destroy the entity

QUEUE node description summary.

Node Type: QUEUE

Symbol:



Function: The QUEUE node is used to delay entities in file IFL until a server becomes available. The QUEUE node initially contains IQ entities and has a capacity of QC entities. The specification of blocking causes incoming entities and servers to be blocked whenever the arriving entity finds the queue is at capacity. The specification of balking causes arriving entities to balk whenever the queue is at capacity. Entities arriving to a full queue will be destroyed if neither balking or blocking is specified.

If a service activity does not immediately follow a QUEUE node, the QUEUE node should reference an associated SELECT node or MATCH node in order to maintain network sequencing. If a QUEUE node has no following SELECT or MATCH nodes and no following service activity, arriving entities will remain in the queue until removed by a call to RMOVE from a user-written subprogram.

Input Format: QUEUE(IFL),IQ,QC,BLOCK or BALK(NLBL),SLBL;

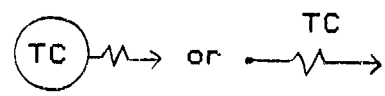
Specifications:

Input Field	Options	Default
IFL	integer between 1 and MFIL	error
IQ	non-negative integer	0
QC	positive integer greater than or equal to IQ	
BLOCK or BALK(NLBL)	BLOCK or BALK(NLBL) where NLBL corresponds to the label of a labeled node	none
SLBLs	the label of SELECT or MATCH nodes separated by commas	none

TERMINATE node description summary.

Node Type: TERMINATE

Symbol:



Function: The TERMINATE node is used to destroy entities and/or terminate the simulation. All incoming entities to a TERMINATE node are destroyed. The arrival of the TCth entity causes a simulation run to be terminated.

Input Format: TERMINATE,TC;

Specifications:

Input Field	Options	Default
TC	positive integer	∞

User Support and Callable Subprograms of SLAM used in Computer Simulation Model

Subroutine Enter (IN,A): Release ENTER node whose number is IN with an entity whose attribute values are in the vector A.

Function NNQ (IFILE): Returns the number of entries in file IFILE.

Subroutine RMOVE (NRANK,IFILE,A): Removes an entry defined by the variable NRANK from a file defined by the variable IFILE. If NRANK is positive, it defines the rank of the entry to be removed. If NRANK is negative, it points to the negative of the location where the entry to be removed is stored. RMOVE loads the vector A with the attributes of the entry removed. The value of MFA is reset to the pointer of the entry removed.

Function TRIAG (XLO,XMODE,XHI,IS): Returns a sample from a triangular distribution in the interval XLO to XHI with mode XMODE, using random number stream IS.

Function UNFRM (ULO,UHI,IS): Returns a sample from a uniform distribution in the interval ULO to UHI, using random number stream IS.

APPENDIX B

PROGRAM LISTING

```
***************************************************************************
***************************************************************************
**                                                                       **
**    In program main, the dimension of the SLAM NSET/QSET array is      **
**    increased from the default value, and the variable NNSET is        **
**    set equal to the dimension of the array.  User common blocks       **
**    are defined here so they will always be defined.  Once the         **
**    SLAM executive program is called, it controls all program          **
**    functions until the simulation is complete.                        **
**                                                                       **
***************************************************************************
***************************************************************************
c
      program main
c
      dimension nset(70000)
c
      common/scom1/atrib(100),dd(100),ddl(100),dtnow,ii,mfa,mstop,nclnr
     *,ncrdr,nprnt,nnrun,nnset,ntape,ss(100),ssl(100),tnext,tnow,xx(100)
      common qset(70000)
c
      common/ucom1/min5s,min7s,min9s,max5s,max7s,max9s,min5a,min7a,
     *min9a,max5a,max7a,max9a
c
      equivalence (nset(1),qset(1))
c
      nnset=70000
      ncrdr=5
      nprnt=6
      ntape=7
      open(7,status='scratch')
c
      call slam
c
      stop
      end
c
```

```
************************************************************************
************************************************************************
**                                                                    **
**    Subroutine event is an optional SLAM insert which allows        **
**    interface of a SLAM network with user-written discrete event    **
**    code.  By this means, processing of normal transactions is      **
**    halted while statistics are collected, or the state of the      **
**    model is altered by direct access to files and activities.      **
**                                                                    **
**    Event 1 initiates the generation of requisitions for all        **
**    classes of supply items for location 1.                         **
**                                                                    **
**    Event 2 initiates the generation of requisitions for all        **
**    classes of supply items for location 2.                         **
**                                                                    **
**    Event 3 determines the quantities, of all classes of supply     **
**    items, that are to be made available from CONUS storage         **
**    locations to fill on-hand requisitions.                         **
**                                                                    **
**    Event 4 determines the quantites, of all classes of supply      **
**    items, that are to be made available from OCONUS storage        **
**    locations, to fill applicable requisitions.                     **
**                                                                    **
**    Event 5 removes all unfilled requisitions from the CONUS        **
**    fill network, and inserts them into the OCONUS fill network.    **
**    If there are any unused inventories, it also resets the         **
**    network for the next operational cycle.                         **
**                                                                    **
**    Event 6 removes all unfilled requisitions from the OCONUS       **
**    fill network, and inserts them into the Recycle/divert          **
**    network. It also resets the OCONUS fill network for the next    **
**    operational cycle.                                              **
**                                                                    **
**    Event 7 configures the pallet loads into shiploads for          **
**    sealift from CONUS to location 1.                               **
**                                                                    **
**    Event 8 configures the pallet loads into planeloads for         **
**    airlift from CONUS to location 1.                               **
**                                                                    **
**    Event 9 configures the pallet loads into shiploads for          **
**    sealift from CONUS to location 2.                               **
**                                                                    **
**    Event 10 configures the pallet loads into planeloads for        **
**    airlift from CONUS to location 2.                               **
**                                                                    **
**    Event 11 configures the pallet loads into planeloads for        **
**    airlift from OCONUS to location 2.                              **
**                                                                    **
**    Event 12 determines if all criteria for diversion of routed     **
**    are met and, if so, triggers the diversion process.             **
**                                                                    **
**    Event 13 removes all unfilled high priority requests from       **
**    the Divert portion of the Recycle/divert network and routes     **
**    them back to the start of the operational cycle.                **
**                                                                    **
**    All terms are defined in the Glossary.                          **
**                                                                    **
************************************************************************
************************************************************************
```

```
c
      subroutine event(ifn)
c
      common/scom1/atrib(100),dd(100),ddl(100),dtnow,ii,mfa,mstop,nclnr
     *,ncrdr,nprnt,nnrun,nnset,ntape,ss(100),ssl(100),tnext,tnow,xx(100)
c
      common/ucom1/min5s,min7s,min9s,max5s,max7s,max9s,min5a,min7a,
     *min9a,max5a,max7a,max9a
c
c     The following arrays are used for carrying attribute values for
c     entities created, moved, or destroyed.
c
      real a(7),b(7),c(7),d(7),a1(7),b1(7),c1(7),d1(7),
     *a2(7),b2(7),c2(7),d2(7),a3(7),b3(7),c3(7),d3(7),
     *a4(7),b4(7),c4(7)
c
      integer base5c,base7c,base9c,base5o,base7o,base9o,aval5c,aval7c,
     *aval9c,aval5o,aval7o,aval9o,hp5rec,hp7rec,hp9rec,sump1s,sump1a,
     *sump2s,sump2a,sump2o
c
      go to (1,2,3,4,5,6,7,8,9,10,11,12,13),ifn
c
c**********************************************************************
c     Generate demands for location 1                                  *
c**********************************************************************
c
1     n1c5=nint(triag(10.,17.,25.,1))
      n1c7=nint(triag(3.,7.,10.,1))
      n1c9=nint(triag(5.,10.,15.,1))
      a(1)=1.0
      a(3)=1.01
      a(4)=1.0
      a(5)=9.0
      a(6)=5.0
      a(7)=tnow
      do 100 i=1,n1c5
       if (tnow.le.30.0) then
```

```
        a(2)=unfrm(3.0,9.0,1)
       else
        a(2)=unfrm(0.0,6.0,1)
       endif
       call enter(1,a)
100    continue
       a(6)=7.0
       do 110 i=1,n1c7
       if (tnow.le.30.0) then
         a(2)=unfrm(3.0,9.0,1)
       else
         a(2)=unfrm(0.0,6.0,1)
       endif
       call enter(1,a)
110    continue
       a(6)=9.0
       do 120 i=1,n1c9
       if (tnow.le.30.0) then
         a(2)=unfrm(3.0,9.0,1)
       else
         a(2)=unfrm(0.0,6.0,1)
       endif
       call enter(1,a)
120    continue
       return
c
c**********************************************************************
c      Generate demands for location 2                               *
c**********************************************************************
c
2      if (tnow.le.30.0) go to 130
       n2c5=nint(triag(10.,17.,25.,1))
       n2c7=nint(triag(3.,7.,10.,1))
       n2c9=nint(triag(5.,10.,15.,1))
       b(1)=2.0
       b(3)=1.05
       b(4)=1.0
       b(5)=1.0
       b(6)=5.0
       b(7)=tnow
       do 140 j=1,n2c5
       if (tnow.le.60.0) then
         b(2)=unfrm(3.0,9.0,1)
       else
         b(2)=unfrm(0.0,6.0,1)
       endif
       call enter(1,b)
140    continue
       b(6)=7.0
       do 150 j=1,n2c7
       if (tnow.le.60.0) then
         b(2)=unfrm(3.0,9.0,1)
       else
         b(2)=unfrm(0.0,6.0,1)
       endif
       call enter(1,b)
```

```
150   continue
      b(6)=9.0
      do 160 j=1,n2c9
      if (tnow.le.60.0) then
        b(2)=unfrm(3.0,9.0,1)
      else
        b(2)=unfrm(0.0,6.0,1)
      endif
      call enter(1,b)
160   continue
130   return
c
c***********************************************************************
c     Determine amounts of CONUS inventory available today            *
c***********************************************************************
c
3     x=unfrm(1.,2.,1)
      y=unfrm(0.5,1.0,1)
      z=unfrm(0.5,1.0,1)
      xx(2)=xx(2)+x
      xx(3)=xx(3)+y
      xx(4)=xx(4)+z
c     inventory increased by new acquisitions
      ic5c=nint(xx(2))
      ic7c=nint(xx(3))
      ic9c=nint(xx(4))
      if (tnow.le.15.0) then
      base5c=1000
      base7c=400
      base9c=600
      else
      if (tnow.gt.15.0.and.tnow.le.30.0) then
      base5c=825
      base7c=350
      base9c=500
      else
      if (tnow.gt.30.0.and.tnow.le.45.0) then
      base5c=400
      base7c=150
      base9c=250
      else
      if (tnow.gt.45.0) then
      base5c=0
      base7c=0
      base9c=0
      endif
      endif
      endif
      endif
      avai5c=ic5c-base5c
      avai7c=ic7c-base7c
      avai9c=ic9c-base9c
      c(1)=3.0
      c(2)=9.0
      c(3)=9.0
      c(4)=1.0
```

```
      c(5)=9.0
      c(6)=5.0
      c(7)=tnow
      if (aval5c.le.0)  go to 180
      do 170 K=1,aval5c
      call enter(2,c)
170   continue
180   if (aval7c.le.0) go to 200
      c(6)=7.0
      do 190 K=1,aval7c
      call enter(2,c)
190   continue
200   if (aval9c.le.0) go to 240
      c(6)=9.0
      do 210 K=1,aval9c
      call enter(2,c)
210   continue
240   return
c
c*************************************************************************
c     Determine amounts of OCONUS inventory available today            *
c*************************************************************************
c
4     if (tnow.le.30.0) go to 250
      ic5o=nint(xx(5))
      ic7o=nint(xx(6))
      ic9o=nint(xx(7))
      base5o=900
      base7o=250
      base9o=100
      unfenc=0.1
      aval5o=nint((ic5o-base5o)*unfenc)
      aval7o=nint((ic7o-base7o)*unfenc)
      aval9o=nint((ic9o-base9o)*unfenc)
      d(1)=4.0
      d(2)=9.0
      d(3)=9.0
      d(4)=9.0
      d(5)=1.0
      d(6)=5.0
      d(7)=tnow
      if (aval5o.le.0) go to 270
      do 260 m=1,aval5o
      call enter(4,d)
260   continue
270   if (aval7o.le.0) go to 290
      d(6)=7.0
      do 280 m=1,aval7o
      call enter(4,d)
280   continue
290   if (aval9o.le.0) go to 250
      d(6)=9.0
      do 300 m=1,aval9o
      call enter(4,d)
300   continue
250   return
```

```
c
c************************************************************************
c      Move all unfilled requisitions from CONUS to OCONUS network      *
c************************************************************************
c
5      m5unf=nnq(1)
       m7unf=nnq(2)
       m9unf=nnq(3)
       m5nuc=nnq(4)
       m7nuc=nnq(5)
       m9nuc=nnq(6)
c
c      The following do-loops move unfilled requisitions to OCONUS cycle
c
       if (m5unf.eq.0) go to 310
       do 305 n=1,m5unf
       call rmove(1,1,a1)
       call enter(3,a1)
305    continue
310    if (m7unf.eq.0) go to 320
       do 315 n=1,m7unf
       call rmove(1,2,a1)
       call enter(3,a1)
315    continue
320    if (m9unf.eq.0) go to 330
       do 325 n=1,m9unf
       call rmove(1,3,a1)
       call enter(3,a1)
325    continue
c
c      The following do-loops reset inventory queues for next cycle
c
330    if (m5nuc.eq.0) go to 340
       do 335 n=1,m5nuc
       call rmove(1,4,a1)
335    continue
340    if (m7nuc.eq.0) go to 350
       do 345 n=1,m7nuc
       call rmove(1,5,a1)
345    continue
350    if (m9nuc.eq.0) go to 360
       do 355 n=1,m9nuc
       call rmove(1,6,a1)
355    continue
360    return
c
c************************************************************************
c      Move unfilled requisitions from OCONUS to Recycle/divert network *
c************************************************************************
c
6      m5rec=nnq(19)
       m7rec=nnq(20)
       m9rec=nnq(21)
       m5nuo=nnq(22)
       m7nuo=nnq(23)
       m9nuo=nnq(24)
```

```
c
c     The following do-loops move unfilled requisitions to recycle
c
      if (m5rec.eq.0) go to 370
      do 365 i1=1,m5rec
      call rmove(1,19,b1)
      call enter(5,b1)
365   continue
370   if (m7rec.eq.0) go to 380
      do 375 i1=1,m7rec
      call rmove(1,20,b1)
      call enter(5,b1)
375   continue
380   if (m9rec.eq.0) go to 390
      do 385 i1=1,m9rec
      call rmove(1,21,b1)
      call enter(5,b1)
385   continue
c
c     The following do-loops reset inventory queues for next cycle
c
390   if (m5nuo.eq.0) go to 400
      do 395 i1=1,m5nuo
      call rmove(1,22,b1)
395   continue
400   if (m7nuo.eq.0) go to 410
      do 405 i1=1,m7nuo
      call rmove(1,23,b1)
405   continue
410   if (m9nuo.eq.0) go to 420
      do 415 i1=1,m9nuo
      call rmove(1,24,b1)
415   continue
420   return
c
c************************************************************************
c     Configure shiploads for sealift from CONUS to destination 1      *
c************************************************************************
c
7     npc51s=nnq(7)
      npc71s=nnq(8)
      npc91s=nnq(9)
      sump1s=npc51s+npc71s+npc91s
      if (npc51s.lt.min5s.or.npc71s.lt.min7s) go to 490
      if (npc91s.lt.min9s.or.sump1s.lt.50) go to 490
      c1(1)=1.0
      c1(2)=xx(1)
      c1(3)=9.0
      if (npc51s.gt.max5s) then
      do 430 j1=1,max5s
      call rmove(1,7,d1)
430   continue
      c1(4)=max5s
      c1(7)=d1(7)
      else
      do 440 j1=1,npc51s
```

```
      call rmove(1,7,d1)
440   continue
      c1(4)=npc51s
      c1(7)=d1(7)
      endif
      if (npc71s.gt.max7s) then
      do 450 j1=1,max7s
      call rmove(1,8,d1)
450   continue
      c1(5)=max7s
      c1(7)=d1(7)
      else
      do 460 j1=1,npc71s
      call rmove(1,8,d1)
460   continue
      c1(5)=npc71s
      c1(7)=d1(7)
      endif
      if (npc91s.gt.max9s) then
      do 470 j1=1,max9s
      call rmove(1,9,d1)
470   continue
      c1(6)=max9s
      c1(7)=d1(7)
      else
      do 480 j1=1,npc91s
      call rmove(1,9,d1)
480   continue
      c1(6)=npc91s
      c1(7)=d1(7)
      endif
      call enter(9,c1)
      xx(1)=xx(1)+1.0
490   return
c
c*********************************************************************
c     Configure planeloads for airlift from CONUS to destination 1      *
c*********************************************************************
c
8     npc51a=nnq(10)
      npc71a=nnq(11)
      npc91a=nnq(12)
      sumpla=npc51a+npc71a+npc91a
      if (npc51a.lt.min5a.or.npc71a.lt.min7a) go to 560
      if (npc91a.lt.min9a.or.sumpla.lt.9) go to 560
      a2(1)=1.0
      a2(2)=xx(1)
      a2(3)=9.0
      if (npc51a.gt.max5a) then
      do 500 K1=1,max5a
      call rmove(1,10,b2)
500   continue
      a2(4)=max5a
      a2(7)=b2(7)
      else
      do 510 K1=1,npc51a
```

```
      call rmove(1,10,b2)
510   continue
      a2(4)=npc51a
      a2(7)=b2(7)
      endif
      if (npc71a.gt.max7a) then
      do 520 K1=1,max7a
      call rmove(1,11,b2)
520   continue
      a2(5)=max7a
      a2(7)=b2(7)
      else
      do 530 K1=1,npc71a
      call rmove(1,11,b2)
530   continue
      a2(5)=npc71a
      a2(7)=b2(7)
      endif
      if (npc91a.gt.max9a) then
      do 540 K1=1,max9a
      call rmove(1,12,b2)
540   continue
      a2(6)=max9a
      a2(7)=b2(7)
      else
      do 550 K1=1,npc91a
      call rmove(1,12,b2)
550   continue
      a2(6)=npc91a
      a2(7)=b2(7)
      endif
      call enter(10,a2)
      xx(1)=xx(1)+1.0
560   return
c
c**********************************************************************
c     Configure shiploads for sealift from CONUS to destination 2     *
c**********************************************************************
c
9     npc52s=nnq(13)
      npc72s=nnq(14)
      npc92s=nnq(15)
      sump2s=npc52s+npc72s+npc92s
      if (npc52s.lt.min5s.or.npc72s.lt.min7s) go to 630
      if (npc92s.lt.min5s.or.sump2s.lt.50) go to 630
      c2(1)=2.0
      c2(2)=xx(1)
      c2(3)=9.0
      if (npc52s.gt.max5s) then
      do 570 m1=1,max5s
      call rmove(1,13,d2)
570   continue
      c2(4)=max5s
      c2(7)=d2(7)
      else
      do 580 m1=1,npc52s
```

```
      call rmove(1,13,d2)
 580  continue
      c2(4)=npc52s
      c2(7)=d2(7)
      endif
      if (npc72s.gt.max7s) then
      do 590 m1=1,max7s
      call rmove(1,14,d2)
 590  continue
      c2(5)=max7s
      c2(7)=d2(7)
      else
      do 600 m1=1,npc72s
      call rmove(1,14,d2)
 600  continue
      c2(5)=npc72s
      c2(7)=d2(7)
      endif
      if (npc92s.gt.max9s) then
      do 610 m1=1,max9s
      call rmove(1,15,d2)
 610  continue
      c2(6)=max9s
      c2(7)=d2(7)
      else
      do 620 m1=1,npc92s
      call rmove(1,15,d2)
 620  continue
      c2(6)=npc92s
      c2(7)=d2(7)
      endif
      call enter(11,c2)
      xx(1)=xx(1)+1.0
 630  return
c
c*********************************************************************
c     Configure planeloads for airlift from CONUS to destination 2   *
c*********************************************************************
c
10    npc52a=nnq(16)
      npc72a=nnq(17)
      npc92a=nnq(18)
      sump2a=npc52a+npc72a+npc92a
      if (npc52a.lt.min5a.or.npc72a.lt.min7a) go to 700
      if (npc92a.lt.min9a.or.sump2a.lt.9) go to 700
      a3(1)=2.0
      a3(2)=xx(1)
      a3(3)=9.0
      if (npc52a.gt.max5a) then
      do 640 n1=1,max5a
      call rmove(1,16,b3)
 640  continue
      a3(4)=max5a
      a3(7)=b3(7)
      else
      do 650 n1=1,npc52a
```

```
      call rmove(1,16,b3)
 650  continue
      a3(4)=npc52a
      a3(7)=b3(7)
      endif
      if (npc72a.gt.max7a) then
      do 660 n1=1,max7a
      call rmove(1,17,b3)
 660  continue
      a3(5)=max7a
      a3(7)=b3(7)
      else
      do 670 n1=1,npc72a
      call rmove(1,17,b3)
 670  continue
      a3(5)=npc72a
      a3(7)=b3(7)
      endif
      if (npc92a.gt.max9a) then
      do 680 n1=1,max9a
      call rmove(1,18,b3)
 680  continue
      a3(6)=max9a
      a3(7)=b3(7)
      else
      do 690 n1=1,npc92a
      call rmove(1,18,b3)
 690  continue
      a3(6)=npc92a
      a3(7)=b3(7)
      endif
      call enter(12,a3)
      xx(1)=xx(1)+1.0
 700  return
c
c*************************************************************************
c     Configure planeloads for airlift from OCONUS to destination 2      *
c*************************************************************************
c
 11   npc52o=nnq(25)
      npc72o=nnq(26)
      npc92o=nnq(27)
      sump2o=npc52o+npc72o+npc92o
      if (npc52o.lt.min5a.or.npc72o.lt.min7a) go to 770
      if (npc92o.lt.min9a.or.sump2o.lt.9) go to 770
      c3(1)=2.0
      c3(2)=xx(1)
      c3(3)=9.0
      if (npc52o.gt.max5a) then
      do 710 i2=1,max5a
      call rmove(1,25,d3)
 710  continue
      c3(4)=max5a
      c3(7)=d3(7)
      else
      do 720 i2=1,npc52o
```

```
      call rmove(1,25,d3)
720   continue
      c3(4)=npc52o
      c3(7)=d3(7)
      endif
      if (npc72o.gt.max7a) then
      do 730 i2=1,max7a
      call rmove(1,26,d3)
730   continue
      c3(5)=max7a
      c3(7)=d3(7)
      else
      do 740 i2=1,npc72o
      call rmove(1,26,d3)
740   continue
      c3(5)=npc72o
      c3(7)=d3(7)
      endif
      if (npc92o.gt.max9a) then
      do 750 i2=1,max9a
      call rmove(1,27,d3)
750   continue
      c3(6)=max9a
      c3(7)=d3(7)
      else
      do 760 i2=1,npc92o
      call rmove(1,27,d3)
760   continue
      c3(6)=npc92o
      c3(7)=d3(7)
      endif
      call enter(13,c3)
      xx(1)=xx(1)+1.0
770   return
c
c*************************************************************************
c     Check if all criteria for diversion are met and, if so, execute    *
c*************************************************************************
c
12    npri5=nnq(28)
      npri7=nnq(29)
      npri9=nnq(30)
      if (npri5.lt.5) go to 810
      ic5d1=nnq(7)
      ic5d2=nnq(10)
      ic5d3=nnq(31)
      ic5d4=nnq(32)
      if (ic5d1.eq.0) go to 780
      call rmove(1,7,a4)
      do 775 j2=1,5
      call enter(1,a4)
775   continue
      a4(1)=2.0
      call enter(6,a4)
      go to 810
780   if (ic5d2.eq.0) go to 790
```

```
      call rmove(1,10,a4)
      do 785 j2=1,5
      call enter(1,a4)
785   continue
      a4(1)=2.0
      call enter(7,a4)
      go to 810
790   if (ic5d3.eq.0) go to 800
      call rmove (1,31,a4)
      if (a4(4).eq.0.) then
      call enter(16,a4)
      go to 800
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=5.0
      b4(7)=a4(7)
      a4(4)=a4(4)-1.0
      call enter(16,a4)
      call enter(14,b4)
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=5.0
      do 795 j2=1,5
      call enter(1,a4)
795   continue
      go to 810
800   if (ic5d4.eq.0) go to 810
      call rmove (1,32,a4)
      if (a4(4).eq.0.) then
      call enter(17,a4)
      go to 810
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=5.0
      b4(7)=a4(7)
      a4(4)=a4(4)-1.0
      call enter(17,a4)
      call enter(15,b4)
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=5.0
      do 805 j2=1,5
      call enter(1,a4)
805   continue
```

```
810   if (npri7.lt.1) go to 850
      ic7d1=nnq(8)
      ic7d2=nnq(11)
      ic7d3=nnq(31)
      ic7d4=nnq(32)
      if (ic7d1.eq.0) go to 820
      call rmove(1,8,a4)
      call enter(1,a4)
      a4(1)=2.0
      call enter(6,a4)
      go to 850
820   if (ic7d2.eq.0) go to 830
      call rmove(1,11,a4)
      call enter(1,a4)
      a4(1)=2.0
      call enter(7,a4)
      go to 850
830   if (ic7d3.eq.0) go to 840
      call rmove (1,31,a4)
      if (a4(5).eq.0.) then
      call enter(16,a4)
      go to 840
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=7.0
      b4(7)=a4(7)
      a4(5)=a4(5)-1.0
      call enter(16,a4)
      call enter(14,b4)
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=7.0
      call enter(1,a4)
      go to 850
840   if (ic7d4.eq.0) go to 850
      call rmove (1,32,a4)
      if (a4(5).eq.0.) then
      call enter(17,a4)
      go to 850
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=7.0
      b4(7)=a4(7)
      a4(5)=a4(5)-1.0
      call enter(17,a4)
      call enter(15,b4)
```

```
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=7.0
      call enter(1,a4)
850   if (npri9.lt.3) go to 890
      ic9d1=nnq(9)
      ic9d2=nnq(12)
      ic9d3=nnq(31)
      ic9d4=nnq(32)
      if (ic9d1.eq.0) go to 860
      call rmove(1,9,a4)
      do 855 j2=1,3
      call enter(1,a4)
855   continue
      a4(1)=2.0
      call enter(6,a4)
      go to 890
860   if (ic9d2.eq.0) go to 870
      call rmove(1,12,a4)
      do 865 j2=1,3
      call enter(1,a4)
865   continue
      a4(1)=2.0
      call enter(7,a4)
      go to 890
870   if (ic9d3.eq.0) go to 880
      call rmove (1,31,a4)
      if (a4(6).eq.0.) then
      call enter(16,a4)
      go to 880
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=9.0
      b4(7)=a4(7)
      a4(6)=a4(6)-1.0
      call enter(16,a4)
      call enter(14,b4)
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=9.0
      do 875 j2=1,3
      call enter(1,a4)
875   continue
      go to 890
880   if (ic9d4.eq.0) go to 890
      call rmove (1,32,a4)
      if (a4(6).eq.0.) then
      call enter(17,a4)
```

```
      go to 890
      endif
      b4(1)=2.0
      b4(2)=8.0
      b4(3)=1.1
      b4(4)=1.0
      b4(5)=1.0
      b4(6)=9.0
      b4(7)=a4(7)
      a4(6)=a4(6)-1.0
      call enter(17,a4)
      call enter(15,b4)
      a4(2)=7.0
      a4(3)=1.1
      a4(4)=1.0
      a4(5)=9.0
      a4(6)=9.0
      do 885 j2=1,3
      call enter(1,a4)
885   continue
890   return
c
c************************************************************************
c     Move all unfilled high priority requisitions back  to start      *
c************************************************************************
c
13    hp5rec=nnq(28)
      hp7rec=nnq(29)
      hp9rec=nnq(30)
      if (hp5rec.eq.0) go to 960
      do 955 m4=1,hp5rec
      call rmove(1,28,c4)
      call enter(8,c4)
955   continue
960   if (hp7rec.eq.0) go to 970
      do 965 m4=1,hp7rec
      call rmove(1,29,c4)
      call enter(8,c4)
965   continue
970   if (hp9rec.eq.0) go to 980
      do 975 m4=1,hp9rec
      call rmove(1,30,c4)
      call enter(8,c4)
975   continue
980   return
c
      end
```

```
************************************************************************
************************************************************************
**                                                                    **
**    Subroutine INTLC is an optional user subroutine which is        **
**    called by SLAM at the beginning of each simulation run, to      **
**    establish the initial conditions for the run.  In this model,   **
**    the global variables, XX(I), are used to establish initial      **
**    inventory levels.  The variables described by user common       **
**    statement, UCOM1, are used to establish minimum and maximum     **
**    standards for cargo configurations.  Specific definitions of    **
**    each term are included in the Glossary.                         **
**                                                                    **
************************************************************************
************************************************************************
c
      subroutine intlc
c
      common/scom1/atrib(100),dd(100),ddl(100),dtnow,ii,mfa,mstop,nclnr
     *,ncrdr,nprnt,nnrun,nnset,ntape,ss(100),ssl(100),tnext,tnow,xx(100)
      common/ucom1/min5s,min7s,min9s,max5s,max7s,max9s,min5a,min7a,
     *min9a,max5a,max7a,max9a
c
c     The variable XX(1) is used to establish shipment numbers for the
c     successive cargos.
c
      xx(1)=1.0
c
c     The variables XX(2) through XX(7) are used as follows:
c
c     XX(2) = initial inventory level of class V items in CONUS
c     XX(3) = initial inventory level of class VII items in CONUS
c     XX(4) = initial inventory level of class IX items in CONUS
c     XX(5) = initial inventory level of class V items in OCONUS
c     XX(6) = initial inventory level of class VII items in OCONUS
c     XX(7) = initial inventory level of class IX items in OCONUS
c
      xx(2)=1275.
      xx(3)=510.
      xx(4)=765.
      xx(5)=1150.
      xx(6)=305.
      xx(7)=175.
c
c     The variables XX(8) through XX(13) are used as follows:
c
c     XX(8) = class V cargos delivered to location 1
c     XX(9) = class VII cargos delivered to location 1
c     XX(10) = class IX cargos delivered to location 1
c     XX(11) = class V cargos delivered to location 2
c     XX(12) = class VII cargos delivered to location 2
c     XX(13) = class IX cargos delivered to location 2
```

```
c     XX(14) = Total number of pallets delivered to location 2
c
      xx(8)=0.
      xx(9)=0.
      xx(10)=0.
      xx(11)=0.
      xx(12)=0.
      xx(13)=0.
      xx(14)=0.
c
c     The following variables are used to determine minimum and
c     maximum standards for cargo configurations.
c
      min5s=10
      min7s=20
      min9s=10
      max5s=15
      max7s=25
      max9s=15
      min5a=2
      min7a=4
      min9a=2
      max5a=3
      max7a=7
      max9a=3
c
      return
      end
```

```
gen,prueitt,thesis,11/18/83,1,,,,,,72;
limits,40,7,5000;
priority/1,hvf(2)/2,hvf(2)/3,hvf(2)/19,hvf(2)/20,hvf(2)/21,hvf(2);
timst,xx(8),Total 5 1 air;
timst,xx(9),Total 7 1 air;
timst,xx(10),Total 9 1 air;
timst,xx(11),Total 5 2 air;
timst,xx(12),Total 7 2 air;
timst,xx(13),Total 9 2 air;
record,tnow,time,0,b,1.0,30.0,90.0,yes;
var,xx(14),x,TOTAL PALLETS,min(50),max(50);
network;
;
;
;       GENERATION NETWORK                                    (see Figure 4)
; --------------------------------------------------------------------------
;
        create,1.,1.;
         activity,0.2,,e1;
         activity,0.1,,e2;
         activity,0.3,,e3;
         activity,0.5,,e4;
         activity,0.4,,e5;
e1      event,1,1;                   Generation of demands for location 1
         activity,90.0,,t1;
e2      event,2,1;                   Generation of demands for location 2
         activity,90.0,,t1;
e3      event,3,1;                 Determination of CONUS stock available
         activity,90.0,,t1;
e4      event,4,1;                Determination of OCONUS stock available
         activity,90.0,,t1;
e5      event,5,1;              Movement of unfilled from CONUS to OCONUS
         activity,0.2,,e6;
e6      event,6,1;             Movement of unfilled from OCONUS to recycle
         activity,0.1,,e13;
e13     event,13,1;                 Movement of high priorities to recycle
         activity,90.0,,t1;
t1      terminate,1;
;
;
;       CONUS FILL NETWORK                             (see Figure 5 series)
; --------------------------------------------------------------------------
;
        enter,1,1;
         activity,,,g8;
g8      goon,1;
         activity,,atrib(6).eq.5.0,q1;
         activity,,atrib(6).eq.7.0,q2;
         activity,,atrib(6).eq.9.0,q3;
q1      queue(1),,,,m1; Queue for class 5 demands,ranked on priority value
```

```
q2      queue(2),,,,m2; Queue for class 7 demands,ranked on priority value
q3      queue(3),,,,m3; Queue for class 9 demands,ranked on priority value
        enter,2,1;
         activity,,atrib(6).eq.5.0,q4;
         activity,,atrib(6).eq.7.0,q5;
         activity,,atrib(6).eq.9.0,q6;
q4      queue(4),,,,m1;
q5      queue(5),,,,m2;
q6      queue(6),,,,m3;
m1      match,4,q1/g1,q4;          Matches class 5 demands with CONUS stocks
m2      match,4,q2/g2,q5;          Matches class 7 demands with CONUS stocks
m3      match,4,q3/g3,q6;          Matches class 9 demands with CONUS stocks
g1      goon,1;
         activity,,atrib(1).eq.1.0,as1;
         activity,,atrib(1).eq.2.0,as2;
as1     assign,xx(2)=xx(2)-1.0,1;   Inventory adjustment for CONUS class 5
         activity,,,ac1;
ac1     accumulate,5,5,last,1;
         activity,,atrib(2).lt.3.0,e7;
         activity,,atrib(2).ge.3.0,e8;
e7      event,7,1;              Configures pallets for sealift to location 1
         activity,,atrib(6).eq.5.0,q7;
         activity,,atrib(6).eq.7.0,q8;
         activity,,atrib(6).eq.9.0,q9;
q7      queue(7);
         activity(1)/1,90.0,,t2;
q8      queue(8);
         activity(1)/2,90.0,,t2;
q9      queue(9);
         activity(1)/3,90.0,,t2;
t2      terminate,1;
e8      event,8,1;              Configures pallets for airlift to location 1
         activity,,atrib(6).eq.5.0,q10;
         activity,,atrib(6).eq.7.0,q11;
         activity,,atrib(6).eq.9.0,q12;
q10     queue(10);
         activity(1)/4,90.0,,t2;
q11     queue(11);
         activity(1)/5,90.0,,t2;
q12     queue(12);
         activity(1)/6,90.0,,t2;
as2     assign,xx(2)=xx(2)-1.0,1;   Inventory adjustment for CONUS class 5
         activity,,,ac2;
ac2     accumulate,5,5,last,1;
         activity,,atrib(2).lt.3.0,e9;
         activity,,atrib(2).ge.3.0,e10;
e9      event,9,1;              Configures pallets for sealift to location 2
         activity,,atrib(6).eq.5.0,q13;
         activity,,atrib(6).eq.7.0,q14;
         activity,,atrib(6).eq.9.0,q15;
q13     queue(13);
         activity(1)/7,90.0,,t2;
q14     queue(14);
         activity(1)/8,90.0,,t2;
q15     queue(15);
         activity(1)/9,90.0,,t2;
```

```
e10    event,10,1;            Configures pallets for airlift to location 2
        activity,,atrib(6).eq.5.0,q16;
        activity,,atrib(6).eq.7.0,q17;
        activity,,atrib(6).eq.9.0,q18;
q16    queue(16);
        activity(1)/10,90.0,,t2;
q17    queue(17);
        activity(1)/11,90.0,,t2;
q18    queue(18);
        activity(1)/12,90.0,,t2;
g2     goon,1;
        activity,,atrib(1).eq.1.0,as3;
        activity,,atrib(1).eq.2.0,as4;
as3    assign,xx(3)=xx(3)-1.0,1;   Inventory adjustment for CONUS class 7
        activity,,,g4;
g4     goon,1;
        activity,,atrib(2).lt.3.0,e7;
        activity,,atrib(2).ge.3.0,e8;
as4    assign,xx(3)=xx(3)-1.0,1;   Inventory adjustment for CONUS class 7
        activity,,,g5;
g5     goon,1;
        activity,,atrib(2).lt.3.0,e9;
        activity,,atrib(2).ge.3.0,e10;
g3     goon,1;
        activity,,atrib(1).eq.1.0,as5;
        activity,,atrib(1).eq.2.0,as6;
as5    assign,xx(4)=xx(4)-1.0,1;   Inventory adjustment for CONUS class 9
        activity,,,ac3;
ac3    accumulate,3,3,last,1;
        activity,,atrib(2).lt.3.0,e7;
        activity,,atrib(2).ge.3.0,e8;
as6    assign,xx(4)=xx(4)-1.0,1;   Inventory adjustment for CONUS class 9
        activity,,,ac4;
ac4    accumulate,3,3,last,1;
        activity,,atrib(2).lt.3.0,e9;
        activity,,atrib(2).ge.3.0,e10;
       enter,6,1;      Re-entry point for cargos diverted from sealift CCP
        activity,triag(0.5,1.,2.),,e10;
       enter,7,1;      Re-entry point for cargos diverted from airlift CCP
        activity,triag(0.5,1.,2.),,e10;
       enter,14,1;     Re-entry point for cargos diverted from sealift POE
        activity,triag(0.5,1.,2.),,e10;
       enter,15,1;     Re-entry point for cargos diverted from airlift POE
        activity,triag(0.5,1.,2.),,e10;
;
;
;      OCONUS FILL NETWORK                              (see Figure 6 series)
; ----------------------------------------------------------------------------
;
       enter,3,1;
        activity,,atrib(6).eq.5.0,q19;
        activity,,atrib(6).eq.7.0,q20;
        activity,,atrib(6).eq.9.0,q21;
q19    queue(19),,,,m4;     Queue for class 5 demands, ranked on priority
q20    queue(20),,,,m5;     Queue for class 7 demands, ranked on priority
q21    queue(21),,,,m6;     Queue for class 9 demands, ranked on priority
```

```
        enter,4,1;
         activity,,atrib(6).eq.5.0,q22;
         activity,,atrib(6).eq.7.0,q23;
         activity,,atrib(6).eq.9.0,q24;
q22     queue(22),,,,m4;
q23     queue(23),,,,m5;
q24     queue(24),,,,m6;
m4      match,5,q19/as7,q22;      Matches class 5 demands with OCONUS stock
m5      match,5,q20/as8,q23;      Matches class 7 demands with OCONUS stock
m6      match,5,q21/as9,q24;      Matches class 9 demands with OCONUS stock
as7     assign,xx(5)=xx(5)-1.0,1;  Inventory adjustment for OCONUS class 5
         activity,,,ac5;
ac5     accumulate,5,5,last,1;
         activity,,,e11;
e11     event,11,1;   Configures airlift pallets from OCONUS to location 2
         activity,,atrib(6).eq.5.0,q25;
         activity,,atrib(6).eq.7.0,q26;
         activity,,atrib(6).eq.9.0,q27;
q25     queue(25);
         activity(1)/13,90.0,,t3;
q26     queue(26);
         activity(1)/14,90.0,,t3;
q27     queue(27);
         activity(1)/15,90.0,,t3;
t3      terminate,1;
as8     assign,xx(6)=xx(6)-1.0,1;  Inventory adjustment for OCONUS class 7
         activity,,,g6;
g6      goon,1;
         activity,,,e11;
as9     assign,xx(7)=xx(7)-1.0,1;  Inventory adjustment for OCONUS class 9
         activity,,,ac6;
ac6     accumulate,3,3,last,1;
         activity,,,e11;
;
;
;       RECYCLE OR DIVERT NETWORK                           (see Figure 7)
; -----------------------------------------------------------------------
;
        enter,5,1;
         activity,,,g7;
g7      goon,1;
         activity,,atrib(1).eq.1.0.or.atrib(2).lt.8.0,as10;
         activity,,atrib(1).eq.2.0.and.atrib(2).ge.8.0,e12;
e12     event,12,1;                Checks to see if diversion is required
         activity,,atrib(6).eq.5.0,q28;
         activity,,atrib(6).eq.7.0,q29;
         activity,,atrib(6).eq.9.0,q30;
q28     queue(29);
         activity(1)/16,90.0,,t3;
q29     queue(29);
         activity(1)/17,90.0,,t3;
q30     queue(30);
         activity(1)/18,90.0,,t3;
as10    assign,atrib(2)=atrib(2)*atrib(3),1; Adjusts priority for recycles
         activity,0.4,,g8;
        enter,8,1;
```

```
      activity,,,as11;
as11  assign,atrib(2)=atrib(2)*atrib(3),1; Adjusts priority for hi-pries
      activity,0.3,,q8;
;
;
;     TRANSPORTATION NETWORK                             (see Figure 8 series)
; ------------------------------------------------------------------------------
;
      enter,9,1;
      activity/19,triag(1.,1.5,3.),,q31;
q31   queue(31);                                       Arrival at sealift POE
      activity(2)/29,triag(3.,4.,5.),,q36;
q36   queue(36);                           Depart sealift POE for location 1
      activity(5)/20,triag(18.,21.,24.),,as14;
as14  assign,xx(8)=xx(8)+atrib(4),xx(9)=xx(9)+atrib(5),
           xx(10)=xx(10)+atrib(6),1;
      activity,,,c1;
c1    colct,int(7),time1,,1;
      activity,90.0,,t4;
      enter,10,1;
      activity/21,triag(1.,1.5,3.),,q32;
q32   queue(32);                                       Arrival at airlift POE
      activity(5)/30,triag(1.,1.5,3.),,q37;
q37   queue(37);                           Depart airlift POE for location 1
      activity(15)/22,triag(5.,7.,9.),,as12;
as12  assign,xx(8)=xx(8)+atrib(4),xx(9)=xx(9)+atrib(5),
           xx(10)=xx(10)+atrib(6),1;
      activity,,,c2;
c2    colct,int(7),time2,,1;
      activity,90.0,,t4;
t4    terminate,1;
      enter,11,1;
      activity/23,triag(1.,1.5,3.),,q33;
q33   queue(33);                                       Arrival at sealift POE
      activity(2)/31,triag(3.,4.,5.),,q38;
q38   queue(38);                           Depart sealift POE for location 2
      activity(5)/24,triag(18.,21.,24.),,as15;
as15  assign,xx(11)=xx(11)+atrib(4),xx(12)=xx(12)+atrib(5),
           xx(13)=xx(13)+atrib(6),1;
      activity,,,c3;
c3    colct,int(7),time3,,1;
      activity,90.0,,t4;
      enter,12,1;                                      Arrival at airlift POE
      activity/25,triag(1.,1.5,3.),,q34;
q34   queue(34);                           Depart airlift POE for location 2
      activity(5)/32,triag(1.,1.5,3.),,q39;
q39   queue(39);
      activity(15)/26,triag(4.,6.,8.),,as13;
as13  assign,xx(11)=xx(11)+atrib(4),xx(12)=xx(12)+atrib(5),
           xx(13)=xx(13)+atrib(6),1;
      assign,xx(14)=xx(14)+atrib(4)+atrib(5)+atrib(6),1;
      activity,,,c4;
      enter,13,1;
      activity/27,triag(0.333,0.4,0.5),,q35;
q35   queue(35);                                       Arrival at airlift POE
      activity(5)/33,triag(0.5,1.,1.5),,q40;
```

```
q40    queue(40);                    Depart OCONUS airlift POE for location 2
        activity(10)/28,triag(2.,4.,6.),,as13;
c4     colct,int(7),time4,,1;
        activity,90.0,,t4;
       enter,16,1;           Re-entry point for ships with cargos removed
        activity,triag(0.5,1.,2.),,q31;
       enter,17,1;          Re-entry point for planes with cargos removed
        activity,triag(0.5,1.,2.),,q32;
       endnetwork;
initialize,0.,90.;
entry/7,0.,0.,0.,0.,0.,0.,0.;
entry/8,0.,0.,0.,0.,0.,0.,0.;
entry/9,0.,0.,0.,0.,0.-0.,0.;
entry/10,0.,0.,0.,0.,0.,0.,0.;
entry/11,0.,0.,0.,0.,0.,0.,0.;
entry/12,0.,0.,0.,0.,0.,0.,0.;
entry/13,0.,0.,0.,0.,0.,0.,0.;
entry/14,0.,0.,0.,0.,0.,0.,0.;
entry/15,0.,0.,0.,0.,0.,0.,0.;
entry/16,0.,0.,0.,0.,0.,0.,0.;
entry/17,0.,0.,0.,0.,0.,0.,0.;
entry/18,0.,0.,0.,0.,0.,0.,0.;
entry/25,0.,0.,0.,0.,0.,0.,0.;
entry/26,0.,0.,0.,0.,0.,0.,0.;
entry/27,0.,0.,0.,0.,0.,0.,0.;
entry/28,0.,0.,0.,0.,0.,0.,0.;
entry/29,0.,0.,0.,0.,0.,0.,0.;
entry/30,0.,0.,0.,0.,0.,0.,0.;
fin;
```

APPENDIX C

GOODNESS OF FIT TEST

```
RUN NAME          GOODNESS OF FIT K-S TEST
VARIABLE LIST     OBSERVATIONS
INPUT MEDIUM      CARD
N OF CASES        10
INPUT FORMAT      FREEFIELD
NPAR TESTS        K-S(UNIFORM 3,9)=OBSERVATIONS
STATISTICS        ALL
READ INPUT DATA

     6.78
     3.76
     4.06
     5.27
     6.53
     8.75
     4.80
     5.13
     5.75
     4.40
```

```
VOGELBACK COMPUTING CENTER
NORTHWESTERN UNIVERSITY

S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION [illegible] -- JUNE 18, 197[illegible]



          RUN NAME           GOODNESS OF FIT K-S TEST
          VARIABLE LIST      OBSERVATIONS
          INPUT MEDIUM       CARD
          N OF CASES         [illegible]
          INPUT FORMAT       FREEFIELD
          NPAR TESTS         K-S(UNIFORM 3,9)=OBSERVATIONS
          STATISTICS         ALL
          READ INPUT DATA

   GIVEN  1 VARIABLES, INITIAL CM ALLOWS FOR  2776 CASES
                       MAXIMUM CM ALLOWS FOR 11336 CASES


   OPTION - 1
   IGNORE MISSING VALUE INDICATORS
   (NO MISSING VALUES DEFINED...OPTION 1 WAS FORCED)


   GOODNESS OF FIT K-S TEST

   FILE    NONAME    (CREATION DATE =    1/[illegible]7/[illegible]4 )

   VARIABLE               N          MEAN       STD DEV

   OBSERVAT              1[illegible]         3.[illegible]23       1.3[illegible]


   GOODNESS OF FIT K-S TEST

   FILE    NONAME    (CREATION DATE =    1/[illegible]7/[illegible]4 )

   - - - - - KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST

      OBSERVAT

   TEST DIST. - UNIFORM (RANGE =          3.0000 TO  9.0000)

              CASES       MAX(ABS DIFF)      MAX(+ DIFF)
               1[illegible]           .[illegible]               .[illegible]

              K-S Z         2-TAILED P       MAX(- DIFF)
               .[illegible]54           .[illegible]6              -.[illegible]
```

APPENDIX D

SPSS ANALYSIS

APPENDIX D.1

FOUR-WAY ANOVA

ALL FACTORS

DATA FOR FOURWAY ANALYSIS

1	1	1	1	7.67
1	1	1	1	7.47
1	1	1	1	7.08
1	1	1	1	7.43
1	1	1	1	7.47
1	1	1	1	7.68
1	1	1	1	7.35
1	1	1	1	6.88
1	1	1	1	7.38
1	1	1	1	7.17
1	1	1	2	7.67
1	1	1	2	7.68
1	1	1	2	7.35
1	1	1	2	6.88
1	1	1	2	7.20
1	1	1	2	7.57
1	1	1	2	7.27
1	1	1	2	7.47
1	1	1	2	7.60
1	1	1	2	7.48
1	1	2	1	6.53
1	1	2	1	5.97
1	1	2	1	6.32
1	1	2	1	6.67
1	1	2	1	6.47
1	1	2	1	6.40
1	1	2	1	6.82
1	1	2	1	6.67
1	1	2	1	6.99
1	1	2	1	6.72
1	1	2	2	6.28
1	1	2	2	6.20
1	1	2	2	6.05
1	1	2	2	6.20
1	1	2	2	6.40
1	1	2	2	6.17
1	1	2	2	6.23
1	1	2	2	6.25
1	1	2	2	5.83
1	1	2	2	6.08
1	2	1	1	7.72
1	2	1	1	7.53
1	2	1	1	7.20
1	2	1	1	7.45
1	2	1	1	7.58
1	2	1	1	7.63
1	2	1	1	7.50
1	2	1	1	7.35
1	2	1	1	7.02
1	2	1	1	7.28
1	2	1	2	7.72

1	2	1	2	7.33
1	2	1	2	7.20
1	2	1	2	7.45
1	2	1	2	7.58
1	2	1	2	7.63
1	2	1	2	7.50
1	2	1	2	7.35
1	2	1	2	7.02
1	2	1	2	7.28
1	2	2	1	6.85
1	2	2	1	6.38
1	2	2	1	6.42
1	2	2	1	6.70
1	2	2	1	6.53
1	2	2	1	6.50
1	2	2	1	6.62
1	2	2	1	6.57
1	2	2	1	6.13
1	2	2	1	6.53
1	2	2	2	6.27
1	2	2	2	5.98
1	2	2	2	6.05
1	2	2	2	6.17
1	2	2	2	6.52
1	2	2	2	6.52
1	2	2	2	6.35
1	2	2	2	6.05
1	2	2	2	6.03
1	2	2	2	6.10
2	1	1	1	5.38
2	1	1	1	5.62
2	1	1	1	5.55
2	1	1	1	5.35
2	1	1	1	5.15
2	1	1		5.43
2	1	1	1	[illegible]
2	1	1	1	5.53
2	1	1	1	5.08
2	1	1	1	5.50
2	1	1	2	5.38
2	1	1	2	5.47
2	1	1	2	5.55
2	1	1	2	5.35
2	1	1	2	5.53
2	1	1	2	5.90
2	1	1	2	5.38
2	1	1	2	5.15
2	1	1	2	5.10
2	1	1	2	5.13
2	1	2	1	4.47
2	1	2	1	4.80
2	1	2	1	5.17
2	1	2	1	4.67
2	1	2	1	4.60
2	1	2	1	4.83
2	1	2	1	5.10

2	1	2	1	4.60
2	1	2	1	4.87
2	1	2	1	5.06
2	1	2	2	3.75
2	1	2	2	3.90
2	1	2	2	3.78
2	1	2	2	3.75
2	1	2	2	4.07
2	1	2	2	4.15
2	1	2	2	3.93
2	1	2	2	3.78
2	1	2	2	3.77
2	1	2	2	3.57
2	2	1	1	5.40
2	2	1	1	5.85
2	2	1	1	5.60
2	2	1	1	5.40
2	2	1	1	5.60
2	2	1	1	5.48
2	2	1	1	5.58
2	2	1	1	5.50
2	2	1	1	5.67
2	2	1	1	5.28
2	2	1	2	5.40
2	2	1	2	5.45
2	2	1	2	5.60
2	2	1	2	5.20
2	2	1	2	5.60
2	2	1	2	5.48
2	2	1	2	3.58
2	2	1	2	5.45
2	2	1	2	5.72
2	2	1	2	5.28
2	2	2	1	4.45
2	2	2	1	5.02
2	2	2	1	5.22
2	2	2	1	4.22
2	2	2	1	4.72
2	2	2	1	4.67
2	2	2	1	4.88
2	2	2	1	4.63
2	2	2	1	5.00
2	2	2	1	4.08
2	2	2	2	3.67
2	2	2	2	3.82
2	2	2	2	3.48
2	2	2	2	3.82
2	2	2	2	3.92
2	2	2	2	3.78
2	2	2	2	3.88
2	2	2	2	3.80
2	2	2	2	4.00
2	2	2	2	3.72

END OF FILE

* * * * * * * * * A N A L Y S I S   O F   V A R I A N C E * * * * * * * * *

```
          PAL
       BY PRI
          FEN
          OCO
          DIV
```

* *

SOURCE OF VARIATION			SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS			215.004	4	53.751	1099.635	.001
PRI			161.785	1	161.785	3309.788	.001
FEN			.003	1	.003	.061	.805
OCO			48.896	1	48.896	1000.317	.001
DIV			4.320	1	4.320	88.374	.001
2-WAY INTERACTIONS			5.337	6	.890	18.199	.001
PRI	FEN		.002	1	.002	.031	.861
PRI	OCO		.179	1	.179	3.660	.058
PRI	DIV		1.048	1	1.048	21.443	.001
FEN	OCO		.117	1	.117	2.397	.124
FEN	DIV		.001	1	.001	.012	.912
OCO	DIV		3.991	1	3.991	81.649	.001
3-WAY INTERACTIONS			.778	4	.194	3.978	.004
PRI	FEN	OCO	.065	1	.065	1.334	.250
PRI	FEN	DIV	.002	1	.002	.036	.850
PRI	OCO	DIV	.672	1	.672	13.750	.001
FEN	OCO	DIV	.039	1	.039	.793	.375
4-WAY INTERACTIONS			.001	1	.001	.026	.872
PRI	FEN DIV	OCO	.001	1	.001	.026	.872
EXPLAINED			221.120	15	14.741	301.578	.001
RESIDUAL			7.039	144	.049		
TOTAL			228.159	159	1.435		

160 CASES WERE PROCESSED.

--EOR--

END OF FILE

APPENDIX D.2

ONEWAY ANOVA

ALL CELLS

DATA FOR ONEWAY ANALYSIS, ALL POLICIES

1.	7.67
1.	7.47
1.	7.08
1.	7.43
1.	7.47
1.	7.68
1.	7.35
1.	6.98
1.	7.38
1.	7.17
2.	7.67
2.	7.68
2.	7.35
2.	6.88
2.	7.20
2.	7.57
2.	7.27
2.	7.47
2.	7.60
2.	7.48
3.	6.53
3.	5.97
3.	6.32
3.	6.67
3.	6.47
3.	6.40
3.	6.82
3.	6.67
3.	6.79
3.	6.72
4.	6.28
4.	6.20
4.	6.05
4.	6.20
4.	6.40
4.	6.17
4.	6.23
4.	6.25
4.	5.83
4.	6.08
5.	7.72
5.	7.53
5.	7.20
5.	7.45
5.	7.58
5.	7.63
5.	7.50
5.	7.35
5.	7.02
5.	7.28
6.	7.72

6.	7.33
6.	7.20
6.	7.45
6.	7.58
6.	7.63
6.	7.50
6.	7.35
6.	7.02
6.	7.28
7.	6.95
7.	6.38
7.	6.42
7.	6.70
7.	6.53
7.	6.50
7.	6.62
7.	6.57
7.	6.13
7.	6.53
8.	6.27
8.	5.98
8.	6.05
8.	6.17
8.	6.32
8.	6.52
8.	6.35
8.	6.05
8.	6.03
8.	6.10
9.	5.38
9.	5.62
9.	5.55
9.	5.35
9.	5.15
9.	5.43
9.	5.65
9.	5.53
9.	5.08
9.	5.50
10.	5.38
10.	5.47
10.	5.55
10.	5.35
10.	5.53
10.	5.90
10.	5.38
10.	5.15
10.	5.10
10.	5.13
11.	4.47
11.	4.80
11.	5.17
11.	4.67
11.	4.60
11.	4.83
11.	5.10

```
 11.  4.60
 11.  4.07
 11.  5.06
 12.  3.75
 12.  3.90
 12.  3.78
 12.  3.75
 12.  4.07
 12.  4.15
 12.  3.93
 12.  3.78
 12.  3.77
 12.  3.57
 13.  5.40
 13.  5.85
 13.  5.60
 13.  5.40
 13.  5.60
 13.  5.48
 13.  5.58
 13.  5.50
 13.  5.67
 13.  5.28
 14.  5.40
 14.  5.45
 14.  5.60
 14.  5.20
 14.  5.60
 14.  5.48
 14.  5.58
 14.  5.50
 14.  5.67
 14.  5.28.
 15.  4.45
 15.  5.02
 15.  5.22
 15.  4.22
 15.  4.72
 15.  4.67
 15.  4.88
 15.  4.63
 15.  5.00
 15.  4.08
 16.  3.67
 16.  3.82
 16.  3.48
 16.  3.82
 16.  3.92
 16.  3.78
 16.  3.88
 16.  3.80
 16.  4.00
 16.  3.7[illegible]
END OF FILE
```

1
T

84/02/29. 10.55.39. PAGE 1

ASD COMPUTER CENTER
WRIGHT-PATTERSON AFB,OHIO

S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 8.3 (NOS) -- MAY 04, 1982

376500 CM MAXIMUM FIELD LENGTH REQUEST

```
RUN NAME          THESIS ANALYSIS
VARIABLE LIST     POLICY,PALLETS
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD

CPU TIME REQUIRED..       .015 SECONDS

ONEWAY            PALLETS BY POLICY( 1,20 )/
                  RANGES=DUNCAN(.05)/
                  RANGES=SCHEFFE(.05)/
STATISTICS        ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE FDATA1
AFTER READING    160 CASES FROM SUBFILE NONAME
```

1THESIS ANALYSIS 84/02/29. 10.55.39. PAGE 2

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS
BY POLICY

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQ.	MEAN SQ.	F RATIO	F PROB
BETWEEN GROUPS	15	221.120	14.741	302.524	0
WITHIN GROUPS	144	7.017	.049		
TOTAL	159	228.137			

GROUP	COUNT	MEAN	STAND. DEV.	STAND. ERROR	MIN.	MAX.	95 P E R C E N T CONF INT FOR MEAN

GRP 1	10	7.36	.25	.08	6.88	7.68	7.18 TO	7.54
GRP 2	10	7.42	.25	.08	6.88	7.68	7.24 TO	7.60
GRP 3	10	6.56	.29	.09	5.97	6.99	6.35 TO	6.76
GRP 4	10	6.17	.15	.05	5.83	6.40	6.06 TO	6.28
GRP 5	10	7.43	.21	.07	7.02	7.72	7.27 TO	7.59
GRP 6	10	7.41	.21	.07	7.02	7.72	7.25 TO	7.56
GRP 7	10	6.52	.19	.06	6.13	6.85	6.38 TO	6.66
GRP 8	10	6.20	.20	.06	5.98	6.52	6.06 TO	6.35
GRP 9	10	5.42	.19	.06	5.08	5.65	5.29 TO	5.56
GRP 10	10	5.39	.24	.08	5.10	5.90	5.22 TO	5.57
GRP 11	10	4.82	.24	.07	4.47	5.17	4.65 TO	4.99
GRP 12	10	3.84	.17	.05	3.57	4.12	3.72 TO	3.97
GRP 13	10	5.54	.16	.05	5.28	5.85	5.42 TO	5.65
GRP 14	10	5.48	.15	.05	5.20	5.67	5.37 TO	5.58
GRP 15	10	4.69	.36	.11	4.08	5.22	4.43 TO	4.95
GRP 16	10	3.79	.14	.05	3.48	4.00	3.69 TO	3.89
TOTAL	160	5.88			3.48	7.72		
UNGROUPED DATA			1.20	.09			5.69 TO	6.06
FIXED EFFECTS MODEL			.22	.02			5.84 TO	5.91
RANDOM EFFECTS MODEL			1.21	.30			5.23 TO	6.52

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE 1.4693

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .1678, P = .041 (APPROX.)
BARTLETT-BOX F = 1.186, P = .276
MAXIMUM VARIANCE / MINIMUM VARIANCE = 6.314

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -

2.80 2.94 3.04 3.11 3.17 3.22 3.26 3.29 3.32 3.34
3.36 3.38 3.39 3.41 3.42

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1561 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

```
GROUP   GRP 16    GRP 12
MEAN    3.7890    3.8450
- - - - - - - - - - - - -

SUBSET  2

GROUP   GRP 15    GRP 11
MEAN    4.6890    4.8170
- - - - - - - - - - - - -

SUBSET  3

GROUP   GRP 10    GRP  9    GRP 14    GRP 13
MEAN    5.3940    5.4240    5.4760    5.5360
- - - - - - - - - - - - - - - - - - - - - -

SUBSET  4

GROUP   GRP  4    GRP  8
MEAN    6.1690    6.2040
- - - - - - - - - - - - -

SUBSET  5

GROUP   GRP  7    GRP  3
MEAN    6.5230    6.5560
- - - - - - - - - - - - -

SUBSET  6

GROUP   GRP  1    GRP  6    GRP  2    GRP  5
MEAN    7.3580    7.4060    7.4170    7.4260
- - - - - - - - - - - - - - - - - - - - - -
```



```
FILE - NONAME   (CREATED -  84/02/29)

VARIABLE PALLETS


MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
     7.22  7.22  7.22  7.22  7.22  7.22  7.22  7.22  7.22  7.22
     7.22  7.22  7.22  7.22  7.22

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
           .1561 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)
```

```
SUBSET  1

GROUP   GRP 16   GRP 12
MEAN    3.7890   3.8450
- - - - - - - - - - - - -

SUBSET  2

GROUP   GRP 15   GRP 11
MEAN    4.6890   4.8170
- - - - - - - - - - - - -

SUBSET  3

GROUP   GRP 10   GRP  9   GRP 14   GRP 13
MEAN    5.3940   5.4240   5.4760   5.5360
- - - - - - - - - - - - - - - - - - - - - - -

SUBSET  4

GROUP   GRP  4   GRP  8   GRP  7   GRP  3
MEAN    6.1690   6.2040   6.5230   6.5560
- - - - - - - - - - - - - - - - - - - - - - -

SUBSET  5

GROUP   GRP  1   GRP  6   GRP  2   GRP  5
MEAN    7.3580   7.4060   7.4170   7.4260
- - - - - - - - - - - - - - - - - - - - - - -
1THESIS ANALYSIS                              84/02/29. 10.55.39. PAGE    5

 CPU TIME REQUIRED..        .222 SECONDS


 TOTAL CPU TIME USED..        .237 SECONDS

 RUN COMPLETED

 NUMBER OF CONTROL CARDS READ  10
 NUMBER OF ERRORS DETECTED      0
S
--EOR--
END OF FILE
??
```

APPENDIX D.3

ONEWAY ANOVA

NO FENCING ALLOWED

DATA FOR ONEWAY ANALYSIS, WITHOUT FENCING

5.	7.72
5.	7.53
5.	7.20
5.	7.45
5.	7.58
5.	7.63
5.	7.50
5.	7.35
5.	7.02
5.	7.28
6.	7.72
6.	7.33
6.	7.20
6.	7.45
6.	7.58
6.	7.63
6.	7.50
6.	7.35
6.	7.02
6.	7.28
7.	6.85
7.	6.38
7.	6.42
7.	6.70
7.	6.53
7.	6.50
7.	6.62
7.	6.57
7.	6.13
7.	6.53
8.	6.27
8.	5.98
8.	6.05
8.	6.17
8.	6.52
8.	6.52
8.	6.35
8.	6.05
8.	6.03
8.	6.10
13.	5.40
13.	5.85
13.	5.60
13.	5.40
13.	5.60
13.	5.48
13.	5.58
13.	5.50
13.	5.67
13.	5.28
14.	5.40

14.	5.45
14.	5.60
14.	5.20
14.	5.60
14.	5.48
14.	5.58
14.	5.50
14.	5.67
14.	5.28
15.	4.45
15.	5.02
15.	5.22
15.	4.22
15.	4.72
15.	4.67
15.	4.88
15.	4.63
15.	5.00
15.	4.08
16.	3.67
16.	3.82
16.	3.48
16.	3.82
16.	3.92
16.	3.78
16.	3.88
16.	3.80
16.	4.00
16.	3.72

END OF FILE

```
1
T
                                          84/02/29. 10.56.39. PAGE     1
      ASD COMPUTER CENTER
      WRIGHT-PATTERSON AFB,OHIO

      S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

      VERSION 8.3 (NOS) -- MAY 04, 1982

      376500 CM MAXIMUM FIELD LENGTH REQUEST


RUN NAME        ONEWAY WITHOUT FENCING
VARIABLE LIST   POLICY,PALLETS
INPUT MEDIUM    CARD
N OF CASES      UNKNOWN
INPUT FORMAT    FREEFIELD

CPU TIME REQUIRED..        .014 SECONDS


ONEWAY          PALLETS BY POLICY( 1,20 )/
                RANGES=DUNCAN(.05)/
                RANGES=SCHEFFE(.05)/
STATISTICS      ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE FDATA1A
AFTER READING      80 CASES FROM SUBFILE NONAME
1ONEWAY WITHOUT FENCING                     84/02/29. 10.56.39. PAGE     2

FILE - NONAME   (CREATED -  84/02/29)

VARIABLE PALLETS
     BY  POLICY

                          ANALYSIS OF VARIANCE

        SOURCE            D.F.    SUM OF SQ.      MEAN SQ. F RATIO  F PROB

BETWEEN GROUPS              7       113.095        16.156 350.657       0

WITHIN  GROUPS             72         3.317          .046

TOTAL                      79       116.413



                        STAND.  STAND.                  95  P E R C E N T
GROUP   COUNT   MEAN     DEV.   ERROR      MIN.     MAX.  CONF INT FOR MEAN
```

GRP 5	10	7.43	.21	.07	7.02	7.72	7.27	TO	7.58
GRP 6	10	7.41	.21	.07	7.02	7.72	7.25	TO	7.56
GRP 7	10	6.52	.19	.06	6.13	6.85	6.38	TO	6.66
GRP 8	10	6.20	.20	.06	5.98	6.52	6.06	TO	6.35
GRP 13	10	5.54	.16	.05	5.28	5.85	5.42	TO	5.65
GRP 14	10	5.48	.15	.05	5.20	5.67	5.37	TO	5.58
GRP 15	10	4.69	.36	.11	4.08	5.22	4.43	TO	4.95
GRP 16	10	3.79	.14	.05	3.48	4.00	3.69	TO	3.89
TOTAL	80	5.88			3.48	7.72			
UNGROUPED DATA			1.21	.14			5.61	TO	6.15
FIXED EFFECTS MODEL			.21	.02			5.83	TO	5.93
RANDOM EFFECTS MODEL			1.27	.45			4.82	TO	6.94

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE 1.6110

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .3549, P = .005 (APPROX.)
BARTLETT-BOX F = 1.754, P = .093
MAXIMUM VARIANCE / MINIMUM VARIANCE = 6.314

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS

MULTIPLE RANGE TEST -

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
2.82 2.97 3.06 3.13 3.19 3.24 3.27

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1518 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP GRP 16
MEAN 3.7890
- - - - - - - - -

SUBSET 2

GROUP GRP 15
MEAN 4.6890

```
- - - - - - - - -

SUBSET  3

GROUP    GRP 14     GRP 13
MEAN     5.4760     5.5360
- - - - - - - - - - - - - -

SUBSET  4

GROUP    GRP  8
MEAN     6.2040
- - - - - - - - -

SUBSET  5

GROUP    GRP  7
MEAN     6.5230
- - - - - - - - -

SUBSET  6

GROUP    GRP  6     GRP  5
MEAN     7.4060     7.4260
- - - - - - - - - - - - - -
1ONEWAY WITHOUT FENCING                    84/02/29. 10.56.39. PAGE    4

FILE - NONAME    (CREATED -  84/02/29)

VARIABLE PALLETS


MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
    5.47  5.47  5.47  5.47  5.47  5.47  5.47

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
          .1518 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP    GRP 16
MEAN     3.7890
- - - - - - - - -

SUBSET  2

GROUP    GRP 15
```

```
MEAN    4.6690
- - - - - - - -

SUBSET  3

GROUP   GRP 14    GRP 13
MEAN    5.4720    5.5360
- - - - - - - - - - - - - -

SUBSET  4

GROUP   GRP  8    GRP  7
MEAN    6.2040    6.5230
- - - - - - - - - - - - - -

SUBSET  5

GROUP   GRP  6    GRP  5
MEAN    7.4060    7.4260
- - - - - - - - - - - - - -
1ONEWAY WITHOUT FENCING                        84/02/29. 10.56.39. PAGE    5

 CPU TIME REQUIRED..       .131 SECONDS


 TOTAL CPU TIME USED..       .147 SECONDS

 RUN COMPLETED

 NUMBER OF CONTROL CARDS READ  10
 NUMBER OF ERRORS DETECTED      0
S
--EOR--
END OF FILE
```

APPENDIX D.4

ONEWAY ANOVA

NO PRIORITY SYSTEM

DATA FOR ONEWAY ANALYSIS, WITHOUT PRIORITY

9.	5.38
9.	5.62
9.	5.55
9.	5.35
9.	5.15
9.	5.43
9.	5.65
9.	5.53
9.	5.08
9.	5.50
10.	5.38
10.	5.47
10.	5.55
10.	5.35
10.	5.53
10.	5.90
10.	5.38
10.	5.15
10.	5.10
10.	5.13
11.	4.47
11.	4.80
11.	5.17
11.	4.67
11.	4.50
11.	4.83
11.	5.10
11.	4.60
11.	4.97
11.	5.06
12.	3.75
12.	3.90
12.	3.78
12.	3.75
12.	4.07
12.	4.15
12.	3.93
12.	3.78
12.	3.77
12.	3.57
13.	5.40
13.	5.85
13.	5.60
13.	5.40
13.	5.60
13.	5.48
13.	5.58
13.	5.50
13.	5.67
13.	5.28
14.	5.40

```
 14.  5.45
 14.  5.60
 14.  5.20
 14.  5.60
 14.  5.48
 14.  5.58
 14.  5.50
 14.  5.67
 14.  5.28
 15.  4.45
 15.  5.02
 15.  5.22
 15.  4.22
 15.  4.72
 15.  4.67
 15.  4.88
 15.  4.63
 15.  5.00
 15.  4.08
 16.  3.57
 16.  3.32
 16.  3.48
 16.  3.82
 16.  3.92
 16.  3.78
 16.  3.88
 16.  3.80
 16.  4.00
 16.  3.72
END OF FILE
```

```
1
T
                                                  84/02/29. 10.57.34. PAGE     1
        ASD COMPUTER CENTER
        WRIGHT-PATTERSON AFB.OHIO

        S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

        VERSION 8.3 (NOS) -- MAY 04, 1982

        376500 CM MAXIMUM FIELD LENGTH REQUEST


RUN NAME          ONEWAY WITHOUT PRIORITY
VARIABLE LIST     POLICY,PALLETS
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD

CPU TIME REQUIRED..        .015 SECONDS


ONEWAY            PALLETS BY POLICY( 1,20 )/
                  RANGES=DUNCAN(.05)/
                  RANGES=SCHEFFE(.05)/
STATISTICS        ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE FDATA1B
AFTER READING      80 CASES FROM SUBFILE NONAME
1ONEWAY WITHOUT PRIORITY                          84/02/29. 10.57.34. PAGE     2

FILE - NONAME   (CREATED -  84/02/29)

VARIABLE PALLETS
     BY  POLICY

                           ANALYSIS OF VARIANCE

         SOURCE            D.F.     SUM OF SQ.      MEAN SQ. F RATIO  F PROB

BETWEEN GROUPS               7        36.470        5.210 110.033       0

WITHIN  GROUPS              72         3.409         .047

TOTAL                       79        39.879



                         STAND.   STAND.                       95  P E R C E N T
GROUP    COUNT    MEAN    DEV.    ERROR      MIN.      MAX.   CONF INT FOR MEAN
```

```
GRP  9    10    5.42    .19    .06    5.08    5.65    5.29 TO    5.56
GRP 10    10    5.39    .24    .08    5.10    5.90    5.22 TO    5.57
GRP 11    10    4.82    .24    .07    4.47    5.17    4.65 TO    4.99
GRP 12    10    3.84    .17    .05    3.57    4.15    3.72 TO    3.97
GRP 13    10    5.54    .16    .05    5.28    5.85    5.42 TO    5.65
GRP 14    10    5.48    .15    .05    5.20    5.67    5.37 TO    5.58
GRP 15    10    4.69    .36    .11    4.08    5.22    4.43 TO    4.95
GRP 16    10    3.79    .14    .05    3.48    4.00    3.69 TO    3.89

TOTAL     80    4.87                  3.48    5.90

     UNGROUPED DATA     .71    .08                    4.71 TO    5.03
  FIXED EFFECTS MODEL   .22    .02                    4.82 TO    4.92
RANDOM EFFECTS MODEL    .72    .26                    4.27 TO    5.47

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN  OMPONENT VARIANCE        .5163


TESTS FOR HOMOGENEITY OF VARIANCES

   COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) =    .3454, P =  .007 (APPROX.)
   BARTLETT-BOX F =                             1.924, P =  .063
   MAXIMUM VARIANCE / MINIMUM VARIANCE =        6.314
1ONEWAY WITHOUT PRIORITY                     84/02/29. 10.57.34. PAGE    3

FILE - NONAME    (CREATED -  84/02/29)

VARIABLE PALLETS


MULTIPLE RANGE TEST    .


DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
    2.82  2.97  3.06  3.13  3.19  3.24  3.27

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
        .1539 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP    GRP 16    GRP 12
MEAN     3.7890    3.8450
- - - - - - - - - - - - - -

SUBSET  2

GROUP    GRP 15    GRP 11
MEAN     4.6890    4.8170
```

```
 - - - - - - - - - - - - -

 SUBSET  3

 GROUP    GRP 10     GRP  9     GRP 14     GRP 13
 MEAN     5.3940     5.4240     5.4760     5.5360
 - - - - - - - - - - - - - - - - - - - - - - - - -
1ONEWAY WITHOUT PRIORITY                          84/02/29. 10.57.34. PAGE     4

 FILE - NONAME    (CREATED -  84/02/29)

 VARIABLE PALLETS


 MULTIPLE RANGE TEST


 SCHEFFE PROCEDURE
 RANGES FOR THE .050 LEVEL -
     5.47  5.47  5.47  5.47  5.47  5.47  5.47

 THE RANGES ABOVE ARE TABULAR VALUES.
 THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
           .1539 * RANGE * SQRT(1/N(I) + 1/N(J))

 HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
 NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
 SUBSET OF THAT SIZE)

 SUBSET  1

 GROUP    GRP 16     GRP 12
 MEAN     3.7890     3.8450
 - - - - - - - - - - - - -

 SUBSET  2

 GROUP    GRP 15     GRP 11
 MEAN     4.6890     4.8170
 - - - - - - - - - - - - -

 SUBSET  3

 GROUP    GRP 10     GRP  9     GRP 14     GRP 13
 MEAN     5.3940     5.4240     5.4760     5.5360
 - - - - - - - - - - - - - - - - - - - - - - - - -
1ONEWAY WITHOUT PRIORITY                          84/02/29. 10.57.34. PAGE     5

 CPU TIME REQUIRED..       .128 SECONDS


 TOTAL CPU TIME USED..       .145 SECONDS
```

APPENDIX D.5

ONEWAY ANOVA

NO OCONUS SUPPLIES

DATA FOR ONEWAY ANALYSIS, WITHOUT OCONUS

3.	6.53
3.	5.97
3.	6.32
3.	6.67
3.	6.47
3.	6.40
3.	6.82
3.	6.67
3.	6.99
3.	6.72
4.	6.28
4.	6.20
4.	6.05
4.	6.20
4.	6.40
4.	6.17
4.	6.23
4.	6.25
4.	5.83
4.	6.08
7.	6.85
7.	6.38
7.	6.42
7.	6.70
7.	6.53
7.	6.50
7.	6.62
7.	6.57
7.	6.13
7.	6.53
8.	6.27
8.	5.98
8.	6.05
8.	6.17
8.	6.52
8.	6.52
8.	6.35
8.	6.05
8.	6.03
8.	6.10
11.	4.47
11.	4.80
11.	5.17
11.	4.67
11.	4.60
11.	4.83
11.	5.10
11.	4.60
11.	4.87
11.	5.06
12.	3.75

12.	3.90
12.	3.78
12.	3.75
12.	4.07
12.	4.15
12.	3.93
12.	3.78
12.	3.77
12.	3.57
15.	4.45
15.	5.02
15.	5.22
15.	4.22
15.	4.72
15.	4.67
15.	4.88
15.	4.63
15.	5.00
15.	4.08
16.	3.67
16.	3.82
16.	3.48
16.	3.82
16.	3.92
16.	3.78
16.	3.88
16.	3.80
16.	4.00
16.	3.72

END OF FILE

1
T

```
ASD COMPUTER CENTER                          84/02/29. 10.58.46. PAGE    1
WRIGHT-PATTERSON AFB,OHIO

S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 8.3 (NOS) -- MAY 04, 1982

376500 CM MAXIMUM FIELD LENGTH REQUEST


RUN NAME          ONEWAY WITHOUT OCONUS
VARIABLE LIST     POLICY,PALLETS
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD

CPU TIME REQUIRED..        .015 SECONDS


ONEWAY            PALLETS BY POLICY( 1,20 )/
                  RANGES=DUNCAN(.05)/
                  RANGES=SCHEFFE(.05)/
STATISTICS        ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE FDATA1C
AFTER READING      80 CASES FROM SUBFILE NONAME
1ONEWAY WITHOUT OCONUS                         84/02/29. 10.58.46. PAGE    2

FILE - NONAME    (CREATED -  84/02/29)

VARIABLE PALLETS
     BY  POLICY
```

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQ.	MEAN SQ.	F RATIO	F PROB
BETWEEN GROUPS	7	96.478	13.783	262.011	0
WITHIN GROUPS	72	3.787	.053		
TOTAL	79	100.265			

GROUP	COUNT	MEAN	STAND. DEV.	STAND. ERROR	MIN.	MAX.	95 PERCENT CONF INT FOR MEAN

GRP 3	10	6.56	.29	.09	5.97	6.99	6.35	TO	6.76
GRP 4	10	6.17	.15	.05	5.83	6.40	6.06	TO	6.28
GRP 7	10	6.52	.19	.06	6.13	6.85	6.38	TO	6.66
GRP 8	10	6.20	.20	.06	5.98	6.52	6.06	TO	6.35
GRP 11	10	4.82	.24	.07	4.47	5.17	4.65	TO	4.99
GRP 12	10	3.84	.17	.05	3.57	4.15	3.72	TO	3.97
GRP 15	10	4.69	.36	.11	4.08	5.22	4.43	TO	4.95
GRP 16	10	3.79	.14	.05	3.48	4.00	3.69	TO	3.89
TOTAL	80	5.32			3.48	6.99			
UNGROUPED DATA			1.13	.13			5.07	TO	5.57
FIXED EFFECTS MODEL			.23	.03			5.27	TO	5.38
RANDOM EFFECTS MODEL			1.17	.42			4.34	TO	6.31

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE 1.3730

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .3109, P = .027 (APPROX.)
BARTLETT-BOX F = 1.847, P = .075
MAXIMUM VARIANCE / MINIMUM VARIANCE = 6.314

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
2.82 2.97 3.06 3.13 3.19 3.24 3.27

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1622 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 16	GRP 12
MEAN	3.7890	3.8430

- - - - - - - - - - - - - -

SUBSET 2

GROUP	GRP 15	GRP 11
MEAN	4.6890	4.8170

```
- - - - - - - - - - - - - -

SUBSET  3

GROUP   GRP  4     GRP  8
MEAN    6.1690     6.2040
- - - - - - - - - - - - - -

SUBSET  4

GROUP   GRP  7     GRP  3
MEAN    6.5230     6.5560
- - - - - - - - - - - - - -
1ONEWAY WITHOUT OCONUS                        84/02/29. 10.58.46. PAGE    4

FILE - NONAME    (CREATED -  84/02/29)

VARIABLE PALLETS


MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
    5.47  5.47  5.47  5.47  5.47  5.47  5.47

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
         .1622 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP   GRP 16     GRP 12
MEAN    3.7890     3.8450
- - - - - - - - - - - - - -

SUBSET  2

GROUP   GRP 15     GRP 11
MEAN    4.6890     4.8170
- - - - - - - - - - - - - -

SUBSET  3

GROUP   GRP  4     GRP  8     GRP  7     GRP  3
MEAN    6.1690     6.2040     6.5230     6.5560
- - - - - - - - - - - - - - - - - - - - - - - -
1ONEWAY WITHOUT OCONUS                        84/02/29. 10.58.46. PAGE    5

CPU TIME REQUIRED..       .124 SECONDS
```

APPENDIX D.6

ONEWAY ANOVA

NO DIVERSION ALLOWED

DATA FOR ONEWAY ANALYSIS, WITHOUT DIVERSION

2.	7.67
2.	7.68
2.	7.35
2.	6.88
2.	7.20
2.	7.57
2.	7.27
2.	7.47
2.	7.60
2.	7.48
4.	6.28
4.	6.20
4.	6.05
4.	6.20
4.	6.40
4.	6.17
4.	6.23
4.	6.25
4.	5.83
4.	6.08
6.	7.72
6.	7.33
6.	7.20
6.	7.45
6.	7.58
6.	7.63
6.	7.50
6.	7.35
6.	7.02
6.	7.28
8.	6.27
8.	5.98
8.	6.05
8.	6.17
8.	6.52
8.	6.52
8.	6.35
8.	6.05
8.	6.03
8.	6.10
10.	5.38
10.	5.47
10.	5.55
10.	5.35
10.	5.53
10.	5.70
10.	5.38
10.	5.15
10.	5.10
10.	5.13
12.	3.75

12.	3.90
12.	3.78
12.	3.75
12.	4.07
12.	4.15
12.	3.93
12.	3.76
12.	3.77
12.	3.57
14.	5.40
14.	5.45
14.	5.60
14.	5.20
14.	5.60
14.	5.48
14.	5.58
14.	5.50
14.	5.67
14.	5.28
16.	3.67
16.	3.82
16.	3.48
16.	3.82
16.	3.92
16.	3.78
16.	3.88
16.	3.80
16.	4.00
16.	3.72

END OF FILE

1
T

84/02/29. 11.03.38. PAGE 1

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376500 CM MAXIMUM FIELD LENGTH REQUEST

```
RUN NAME         ONEWAY WITHOUT DIVERSION
VARIABLE LIST    POLICY,PALLETS
INPUT MEDIUM     CARD
N OF CASES       UNKNOWN
INPUT FORMAT     FREEFIELD

CPU TIME REQUIRED..        .011 SECONDS

ONEWAY           PALLETS BY POLICY( 1,20 )/
                 RANGES=DUNCAN(.05)/
                 RANGES=SCHEFFE(.05)/
STATISTICS       ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE FDATA1D
AFTER READING      80 CASES FROM SUBFILE NONAME
```

1ONEWAY WITHOUT DIVERSION 84/02/29. 11.03.38. PAGE 2

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS
BY POLICY

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQ.	MEAN SQ.	F RATIO	F PROB
BETWEEN GROUPS	7	135.680	19.383	513.794	0
WITHIN GROUPS	72	2.716	.038		
TOTAL	79	138.396			

GROUP	COUNT	MEAN	STAND. DEV.	STAND. ERROR	MIN.	MAX.	95 PERCENT CONF INT FOR MEAN

GRP 2	10	7.42	.25	.08	6.88	7.68	7.24 TO	7.60
GRP 4	10	6.17	.15	.05	5.83	6.40	6.06 TO	6.28
GRP 6	10	7.41	.21	.07	7.02	7.72	7.25 TO	7.56
GRP 8	10	6.20	.20	.06	5.98	6.52	6.06 TO	6.35
GRP 10	10	5.39	.24	.08	5.10	5.90	5.22 TO	5.57
GRP 12	10	3.84	.17	.05	3.57	4.15	3.72 TO	3.97
GRP 14	10	5.48	.15	.05	5.20	5.67	5.37 TO	5.58
GRP 16	10	3.79	.14	.05	3.48	4.00	3.69 TO	3.89
TOTAL	80	5.71			3.48	7.72		
UNGROUPED DATA			1.32	.15			5.42 TO	6.01
FIXED EFFECTS MODEL			.19	.02			5.67 TO	5.76
RANDOM EFFECTS MODEL			1.39	.49			4.55 TO	6.88

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE 1.9345

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .2056, P = .669 (APPROX.)
BARTLETT-BOX F = .816, P = .574
MAXIMUM VARIANCE / MINIMUM VARIANCE = 2.994

FILE - NONAME (CREATED - 84/02/29)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
2.82 2.97 3.06 3.13 3.19 3.24 3.27

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1373 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 16	GRP 12
MEAN	3.7890	3.8450

- - - - - - - - - - - - - -

SUBSET 2

GROUP	GRP 10	GRP 14
MEAN	5.3940	5.4760

```
- - - - - - - - - - - - - -

SUBSET  3

GROUP    GRP  4     GRP  8
MEAN     6.1690     6.2040
- - - - - - - - - - - - - -

SUBSET  4

GROUP    GRP  6     GRP  2
MEAN     7.4060     7.4170
- - - - - - - - - - - - - -
1ONEWAY WITHOUT DIVERSION                          84/02/29. 11.03.38. PAGE    4

FILE - NONAME   (CREATED -  84/02/29)

VARIABLE PALLETS


MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
    5.47  5.47  5.47  5.47  5.47  5.47  5.47

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
         .1373 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP    GRP 16     GRP 12
MEAN     3.7890     3.8450
- - - - - - - - - - - - - -

SUBSET  2

GROUP    GRP 10     GRP 14
MEAN     5.3940     5.4760
- - - - - - - - - - - - - -

SUBSET  3

GROUP    GRP  4     GRP  8
MEAN     6.1690     6.2040
- - - - - - - - - - - - - -

SUBSET  4

GROUP    GRP  6     GRP  2
```

```
 MEAN     7.4060    7.4170
 - - - - - - - - - - - - - -
1ONEWAY WITHOUT DIVERSION                        84/02/29. 11.03.38. PAGE    5

 CPU TIME REQUIRED..       .124 SECONDS


 TOTAL CPU TIME USED..       .137 SECONDS

 RUN COMPLETED

 NUMBER OF CONTROL CARDS READ  10
 NUMBER OF ERRORS DETECTED      0
S
--EOR--
END OF FILE
```

APPENDIX E

PILOT RUN DATA

(SAMPLE SIZE)

APPENDIX E

Run Number	MOE
1	1.750
2	1.917
3	1.833
4	1.917
5	1.750
6	1.833
7	1.583
8	2.000
9	1.917
10	1.833
11	2.000
12	1.833
13	2.000
14	1.667
15	1.667
16	1.750
17	1.833
18	1.917
19	1.833
20	1.833

APPENDIX F

SENSITIVITY ANALYSIS

APPENDIX F.1.

PRIORITY IMPROVEMENT RATE DATA

APPENDIX F.1.

Priority Improvement Rate Data

Experiment Call Data - 1.01 for location 1
1.05 for location 2

6.85
6.38
6.42
6.70

Sensitivity Data - both rates at 1.05

6.83
6.38
6.28
6.70

Sensitivity Data - 1.01 for location 1
1.1 for location 2

6.85
6.38
6.42
6.78

Sensitivity Data - 1.1 for location 1
1.01 for location 2

6.68
6.18
6.30
6.53

APPENDIX F.2.

SPSS ONEWAY

ANALYSIS OF PRIORITY

IMPROVEMENT RATES

```
1
T
                                        84/02/09. 13.17.44. PAGE     1
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      376500 CM MAXIMUM FIELD LENGTH REQUEST


RUN NAME          APPENDIX F 2
VARIABLE LIST     POLICY,PALLETS
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD

CPU TIME REQUIRED..        .013 SECONDS


ONEWAY            PALLETS BY POLICY( 1,20 )/
                  RANGES=DUNCAN(.05)/
                  RANGES=SCHEFFE(.05)/
STATISTICS        ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE AF1DATA
AFTER READING      16 CASES FROM SUBFILE NONAME
1APPENDIX F 2                           84/02/09. 13.17.44. PAGE     2

FILE - NONAME   (CREATED -  84/02/09)

VARIABLE PALLETS
     BY  POLICY

                         ANALYSIS OF VARIANCE

        SOURCE           D.F.     SUM OF SQ.       MEAN SQ.  F RATIO  F PROB

BETWEEN GROUPS             3          .083           .028     .485     .699

WITHIN  GROUPS            12          .682           .057

TOTAL                     15          .765



                        STAND.   STAND.                       95  P E R C E N T
GROUP    COUNT    MEAN    DEV.    ERROR      MIN.     MAX.   CONF INT FOR MEAN
```

GRP 1	4	6.59	.23	.11	6.38	6.85	6.23 TO	6.95
GRP 2	4	6.55	.26	.13	6.28	6.83	6.13 TO	6.96
GRP 3	4	6.61	.24	.12	6.38	6.85	6.22 TO	6.99
GRP 4	4	6.42	.22	.11	6.18	6.68	6.06 TO	6.78
TOTAL	16	6.54			6.18	6.85		
UNGROUPED DATA			.23	.06			6.42 TO	6.66
FIXED EFFECTS MODEL			.24	.06			6.41 TO	6.67
RANDOM EFFECTS MODEL			.12	.06			6.35 TO	6.73

WARNING - BETWEEN COMPONENT VARIANCE ESTIMATE IS NEGATIVE. IT WAS
REPLACED BY 0.0 IN COMPUTING ABOVE RANDOM EFFECTS MEASURES.

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE -.0073

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .2970, P = 1.000 (APPROX.)
BARTLETT-BOX F = .025, P = .995
MAXIMUM VARIANCE / MINIMUM VARIANCE = 1.336

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
3.08 3.22 3.32

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1686 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 4	GRP 2	GRP 1	GRP 3
MEAN	6.4225	6.5475	6.5875	6.6075

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

```
MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
    4.58  4.58  4.58

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
         .1686 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP    GRP  4    GRP  2    GRP  1    GRP  3
MEAN     6.4225    6.5475    6.5875    6.6075
- - - - - - - - - - - - - - - - - - - - - - -
1APPENDIX F 2                              84/02/09. 13.17.44. PAGE    5


CPU TIME REQUIRED..        .059 SECONDS



TOTAL CPU TIME USED..        .074 SECONDS


RUN COMPLETED

NUMBER OF CONTROL CARDS READ  10
NUMBER OF ERRORS DETECTED      0
5
--EOR--
END OF FILE
```

APPENDIX F.3.

DATA FOR ALL CELLS,

WITH QUEUES WORKING

ON FIFO BASIS

1.	6.70
1.	6.15
1.	5.98
1.	6.50
2.	6.70
2.	6.52
2.	6.17
2.	6.98
3.	4.83
3.	4.85
3.	4.42
3.	4.85
4.	4.60
4.	4.67
4.	4.72
4.	4.55
5.	6.32
5.	6.35
5.	6.07
5.	6.43
6.	6.67
6.	6.73
6.	6.40
6.	6.42
7.	4.58
7.	4.63
7.	4.37
7.	4.62
8.	4.58
8.	5.18
8.	5.02
8.	4.93
9.	7.00
9.	5.95
9.	5.97
9.	6.23
10.	5.37
10.	5.43
10.	5.17
10.	5.35
11.	5.03
11.	4.77
11.	4.12
11.	4.50
12.	3.82
12.	3.88
12.	3.87
12.	3.60
13.	6.32
13.	6.50
13.	6.02
13.	6.20
14.	5.52
14.	5.15
14.	5.43

14.	5.22
15.	4.57
15.	5.10
15.	4.53
15.	4.50
16.	3.95
16.	3.80
16.	3.73
16.	3.75

END OF FILE

APPENDIX F.4.

SPSS ONEWAY ANALYSIS

OF SIMULATION

WITH QUEUES FIFO

1
T

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376500 CM MAXIMUM FIELD LENGTH REQUEST

```
RUN NAME          APPENDIX F 4
VARIABLE LIST     POLICY,PALLETS
INPUT MEDIUM      CARD
N OF CASES        UNKNOWN
INPUT FORMAT      FREEFIELD

CPU TIME REQUIRED..        .013 SECONDS

ONEWAY            PALLETS BY POLICY( 1,20 )/
                  RANGES=DUNCAN(.05)/
                  RANGES=SCHEFFE(.05)/
STATISTICS        ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE AF3DATA
AFTER READING    . 64 CASES FROM SUBFILE NONAME
```


FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS
BY POLICY

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQ.	MEAN SQ.	F RATIO	F PROB
BETWEEN GROUPS	15	56.114	3.741	60.484	.000
WITHIN GROUPS	48	2.969	.062		
TOTAL	63	59.08			

GROUP	COUNT	MEAN	STAND. DEV.	STAND. ERROR	MIN.	MAX.	95 P E R C E N T CONF INT FOR MEAN

GRP 1	4	6.33	.33	.16	5.98	6.70	5.81 TO	6.85
GRP 2	4	6.59	.34	.17	6.17	6.98	6.05 TO	7.13
GRP 3	4	4.74	.21	.11	4.42	4.85	4.40 TO	5.07
GRP 4	4	4.63	.08	.04	4.55	4.72	4.52 TO	4.75
GRP 5	4	6.29	.16	.08	6.07	6.43	6.05 TO	6.54
GRP 6	4	6.55	.17	.08	6.40	6.73	6.29 TO	6.82
GRP 7	4	4.55	.12	.06	4.37	4.63	4.36 TO	4.74
GRP 8	4	4.93	.25	.13	4.58	5.18	4.52 TO	5.33
GRP 9	4	6.29	.49	.25	5.95	7.00	5.50 TO	7.07
GRP 10	4	5.33	.11	.06	5.17	5.43	5.15 TO	5.51
GRP 11	4	4.60	.39	.19	4.12	5.03	3.99 TO	5.22
GRP 12	4	3.79	.13	.07	3.60	3.88	3.58 TO	4.00
GRP 13	4	6.26	.20	.10	6.02	6.50	5.94 TO	6.58
GRP 14	4	5.33	.17	.09	5.15	5.52	5.05 TO	5.61
GRP 15	4	4.67	.28	.14	4.50	5.10	4.22 TO	5.13
GRP 16	4	3.81	.10	.05	3.73	3.95	3.65 TO	3.97
TOTAL	64	5.29			3.60	7.00		
UNGROUPED DATA			.97	.12			5.05 TO	5.54
FIXED EFFECTS MODEL			.25	.03			5.23 TO	5.36
RANDOM EFFECTS MODEL			.97	.24			4.78 TO	5.81

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE .9198

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .2444, P = .083 (APPROX.)
BARTLETT-BOX F = 1.431, P = .125
MAXIMUM VARIANCE / MINIMUM VARIANCE = 42.939

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
2.84 2.99 3.09 3.16 3.21 3.26 3.29 3.32 3.35 3.37
3.39 3.40 3.41 3.42 3.43

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1759 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 12	GRP 16
MEAN	3.7925	3.8075

SUBSET 2

GROUP	GRP 7	GRP 11	GRP 4	GRP 15	GRP 3	GRP 8
MEAN	4.5500	4.6050	4.6350	4.6750	4.7375	4.9275

SUBSET 3

GROUP	GRP 10	GRP 14
MEAN	5.3300	5.3300

SUBSET 4

GROUP	GRP 13	GRP 9	GRP 5	GRP 1	GRP 6	GRP 2
MEAN	6.2600	6.2875	6.2925	6.3325	6.5550	6.5925

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

MULTIPLE RANGE TEST

SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -

7.51 7.51 7.51 7.51 7.51 7.51 7.51 7.51 7.51 7.51
7.51 7.51 7.51 7.51 7.51

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1759 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 12	GRP 16	GRP 7	GRP 11	GRP 4	GRP 15
MEAN	3.7925	3.8075	4.5500	4.6050	4.6350	4.6750

SUBSET 2

GROUP	GRP 16	GRP 7	GRP 11	GRP 4	GRP 15	GRP 3
MEAN	3.8075	4.5500	4.6050	4.6350	4.6750	4.7375

SUBSET 3

GROUP	GRP 7	GRP 11	GRP 4	GRP 15	GRP 3	GRP 8
MEAN	4.5500	4.6050	4.6350	4.6750	4.7375	4.9275

GROUP	GRP 10	GRP 14
MEAN	5.3300	5.3300

SUBSET 4

GROUP	GRP 10	GRP 14	GRP 13
MEAN	5.3300	5.3300	6.2600

SUBSET 5

GROUP	GRP 13	GRP 9	GRP 5	GRP 1	GRP 6	GRP 2
MEAN	6.2600	6.2875	6.2925	6.3325	6.5550	6.5925

CPU TIME REQUIRED.. .132 SECONDS

TOTAL CPU TIME USED.. .148 SECONDS

RUN COMPLETED

NUMBER OF CONTROL CARDS READ 10
NUMBER OF ERRORS DETECTED 0
S
--EOR--
END OF FILE

APPENDIX F.5.

OCONUS DAILY RELEASE

RATE DATA

Appendix F.5.

OCONUS Daily Release Rate Data

Releasing 5 percent of remaining usable total per day

5.07
5.23
5.27
4.93

Releasing 20 percent of remaining usable total per day

5.35
5.32
5.52
5.05

Releasing 50 percent of remaining usable total per daya

5.32
5.12
5.52
4.98

Releasing 100 percent of remaining usable total per day

5.32
5.12
5.52
4.93

APPENDIX F.6.

SPSS ONEWAY ANALYSIS

OF OCONUS DAILY RELEASE RATES

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376500 CM MAXIMUM FIELD LENGTH REQUEST

```
RUN NAME         APPENDIX F 6
VARIABLE LIST    POLICY,PALLETS
INPUT MEDIUM     CARD
N OF CASES       UNKNOWN
INPUT FORMAT     FREEFIELD

CPU TIME REQUIRED..       .013 SECONDS

ONEWAY           PALLETS BY POLICY( 1,20 )/
                 RANGES=DUNCAN(.05)/
                 RANGES=SCHEFFE(.05)/
STATISTICS       ALL
READ INPUT DATA

00045000 CM NEEDED FOR ONEWAY

END OF FILE ON FILE AF5DATA
AFTER READING      16 CASES FROM SUBFILE NONAME
```


FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS
BY POLICY

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQ.	MEAN SQ.	F RATIO	F PROB
BETWEEN GROUPS	3	.069	.023	.506	.685
WITHIN GROUPS	12	.547	.046		
TOTAL	15	.617			

GROUP	COUNT	MEAN	STAND. DEV.	STAND. ERROR	MIN.	MAX.	95 PERCENT CONF INT FOR MEAN

GRP 1	4	5.13	.16	.08	4.93	5.27	4.88 TO	3.37
GRP 2	4	5.31	.19	.10	5.05	5.52	5.00 TO	5.62
GRP 3	4	5.23	.24	.12	4.98	5.52	4.86 TO	5.61
GRP 4	4	5.22	.25	.13	4.93	5.52	4.82 TO	5.63
TOTAL	16	5.22			4.93	5.52		
UNGROUPED DATA			.20	.05			5.12 TO	5.33
FIXED EFFECTS MODEL			.21	.05			5.11 TO	5.34
RANDOM EFFECTS MODEL			.11	.05			5.05 TO	5.39

WARNING - BETWEEN COMPONENT VARIANCE ESTIMATE IS NEGATIVE. IT WAS REPLACED BY 0.0 IN COMPUTING ABOVE RANDOM EFFECTS MEASURES.

RANDOM EFFECTS MODEL - ESTIM. OF BETWEEN COMPONENT VARIANCE -.0056

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX.VARIANCE/SUM(VARIANCES) = .3546, P = .986 (APPROX.)
BARTLETT-BOX F = .233, P = .873
MAXIMUM VARIANCE / MINIMUM VARIANCE = 2.655

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

MULTIPLE RANGE TEST

DUNCAN PROCEDURE
RANGES FOR THE .050 LEVEL -
3.08 3.22 3.32

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
.1510 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	GRP 1	GRP 4	GRP 3	GRP 2
MEAN	5.1250	5.2225	5.2350	5.3100

FILE - NONAME (CREATED - 84/02/09)

VARIABLE PALLETS

```
MULTIPLE RANGE TEST


SCHEFFE PROCEDURE
RANGES FOR THE .050 LEVEL -
    4.58  4.58  4.58

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH  MEAN(J)-MEAN(I) IS..
         .1510 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS  (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET  1

GROUP    GRP  1     GRP  4     GRP  3     GRP  2
MEAN     5.1250     5.2225     5.2350     5.3100
- - - - - - - - - - - - - - - - - - - - - - - - -
1APPENDIX F 6                              84/02/09. 13.20.11. PAGE    5


CPU TIME REQUIRED..        .058 SECONDS


TOTAL CPU TIME USED..       .073 SECONDS


RUN COMPLETED

NUMBER OF CONTROL CARDS READ  10
NUMBER OF ERRORS DETECTED      0
S
--EOR--
END OF FILE
```

APPENDIX F.7.

COMPARATIVE ANALYSIS

OF OCONUS AND PRIORITY POLICIES

Appendix F.7.

Comparative Analysis of OCONUS and Priority Policies

MOE with OCONUS at 10 percent of CONUS total

5.40
5.45 $\qquad X1 = 5.4125$
5.60
5.20

MOE with OCONUS at 20 percent of CONUS total

7.08
7.10 $\qquad X2 = 7.1025$
7.35
6.88

MOE with just Priority Policy

6.27
5.98 $\qquad X3 = 6.1175$
6.05
6.17

Assuming linear properties

$$\frac{X3 - X1}{X2 - X1} = \frac{.7050}{1.690} = .41$$

OCONUS at approximately 14% of CONUS total

APPENDIX F.8.

POE DIVERSION ANALYSIS

Appendix F.8.

POE Diversion Analysis

a. Allowing Priority, Diversion, and OCONUS Policies only

Experiment cell data - cargos fully transportable

7.72
7.53
7.20
7.45

Requiring increased queuing time at POE's

7.72
7.53
7.20
7.45

b. Allowing Priority and Diversion Policies only

Experiment cell data - cargos fully transportable

6.85
6.38
6.42 $X1 = 6.59$
6.70

Requiring increased queuing time at POE's

7.38
7.23
7.00 $X2 = 7.36$
7.83

12% Increase X2 to X1

APPENDIX G

MODEL DATA DICTIONARY

Appendix G

Model Data Dictionary

-A-

aval5c = number of class V items available for issue, from CONUS sources, for a given operational cycle.

aval7c = number of class VII items available for issue, from CONUS sources, for a given operational cycle

aval9c = number of class IX items available for issue, from CONUS sources, for a given operational cycle

aval5o = number of class V items available for issue, from OCONUS sources, for a given operational cycle

aval7o = number of class VII items available for issue, from OCONUS sources, for a given operational cycle

aval9o = number of class IX items available for issue, from OCONUS sources, for a given operational cycle

-B-

base5c = minimum allowable stockage level of class V items in CONUS locations

base7c = minimum allowable stockage level of class VII items in CONUS locations

base9c = minimum allowable stockage level of class IX items in CONUS locations

base5o = minimum allowable stockage level of class V items in OCONUS locations

base7o = minimum allowable stockage level of class VII items in OCONUS locations

base9o = minimum allowable stockage level of class IX items in OCONUS locations

-H-

hp5rec = number of unfilled high priority class V requisitions, to be recycled

hp7rec = number of unfilled high priority class VII requisitions, to be recycled

hp9rec = number of unfilled high priority class IX requisitions, to be recycled

-I-

ic5c = total number of class V items in CONUS inventories

ic7c = total number of class VII items in CONUS inventories

ic9c = total number of class IX items in CONUS inventories

ic5o = total number of class V items in OCONUS inventories

ic7o = total number of class VII items in OCONUS inventories

ic9o = total number of class IX items in OCONUS inventories

ic5d1 = number of divertable class V pallets at diversion point 1, sealift CCP

ic5d2 = number of divertable class V pallets at diversion point 2, airlift CCP

ic5d3 = number of divertable class V pallets at diversion point 3, sealit POE

ic5d4 = number of divertable class V pallets at diversion point 4, airlift POE

ic7d1 = number of divertable class VII pallets at diversion point 1, sealift CCP

ic7d2 = number of divertable class VII pallets at diversion point 2, airlift CCP

ic7d3 = number of divertable class VII pallets at diversion point 3, sealift POE

ic7d4 = number of divertable class VII pallets at diversion point 4, airlift POE

ic9d1 = number of divertable class IX pallets at diversion point 1, sealift CCP

ic9d2 = number of divertable class IX pallets at diversion point 2, airlift CCP

ic9d3 = number of divertable class IX pallets at diversion point 3, sealift POE

ic9d4 = number of divertable class IX pallets at diversion point 4, airlift POE

-M-

Max5a = maximum number of class V pallets allowed per aircraft cargo configuration

Max7a = maximum number of class VII pallets allowed per aircraft cargo configuration

Max9a = maximum number of class IX pallets allowed per aircraft cargo configuration

Max5s = maximum number of class V pallets allowed per ship cargo configuration

Max7s = maximum number of class VII pallets allowed per ship cargo configuration

Max9s = maximum number of class IX pallets allowed per ship cargo configuration

min5a = minimum number of class V pallets necessary for an aircraft load configuration

min7a = minimum number of class VII pallets necessary for an aircraft load configuration

min9a = minimum number of class IX pallets necessary for an aircraft load configuration
min5s = minimum number of class V pallets necessary for a shipload configuration
min7s = minimum number of class VII pallets necessary for a shipload configuration
min9s = minimum number of class IX pallets necessary for a shipload configuration
m5nuc = number of unused class V items, from CONUS sources, in a given operational cycle
m7nuc = number of unused class VII items, from CONUS sources, in a given operational cycle
m9nuc = number of unused class IX items, from CONUS sources, in a given operational cycle
m5nuo = number of unused class V items, from OCONUS sources, in a given operational cycle
m7nuo = number of unused class VII items, from OCONUS sources, in a given operational cycle
m9nuo = number of unused class IX items, from OCONUS
m5unf = number of unfilled class V requisitions that have to be moved from CONUS to OCONUS fill networks
m7unf = number of unfilled class VII requisitions that have to be moved from CONUS to OCONUS fill networks
m9unf = number of unfilled class IX requisitions that have to be moved from CONUS to OCONUS fill networks
m5rec = number of unfilled class V requisitions that have to be recycled to the next operational cycle
m7rec = number of unfilled class VII requisitions that have to be recycled to the next operational cycle
m9rec = number of unfilled class IX requisitions that have to be recycled to the next operational cycle

-N-

npc51a = number of pallets of class V items for destination 1, waiting airlift configuration
npc71a = number of pallets of class VII items for destination 1, waiting airlift configuration
npc91a = number of pallets of class IX items for destination 1, waiting airlift configuration
npc51s = number of pallets of class V items for destination 1. waiting sealift configuration
npc71s = number of pallets of class VII items for destination 1, waiting sealift configuration
npc91s = number of pallets of class IX items for destination 1, waiting sealift configuration
npc52a = number of pallets of class V items for destination 2, waiting airlift configuration
npc72a = number of pallets of class VII items for destination 2, waiting airlift configuration

npc92a = number of pallets of class IX items for destination 2, waiting airlift configuration

npc52s = number of pallets of class V items for destination 2, waiting sealift configuration

npc72s = number of pallets of class VII items for destination 2, waiting sealift configuration

npc92s = number of pallets of class IX items for destination 2, waiting sealift configuration

npc52o = number of pallets of class V items, from OCONUS, for destination 2, waiting airlift configuration

npc72o = number of pallets of class VII items, from OCONUS, for destination 2, waiting airlift configuration

npc92o = number of pallets of class IX items, from OCONUS, for destination 2, waiting airlift configuration

npri5 = number of high priority class V requisitions, presently only fillable by diversion

npri7 = number of high priority class VII requisitions, presently only fillable by diversion

npri9 = number of high priority class IX requisitions, presently only fillable by diversion

n1c5 = number of new class V requisitions received from destination 1, daily transaction

n1c7 = number of new class VII requisitions received from destination 1, daily transaction

n1c9 = number of new class IX requisitions received from destination 1, daily transaction

n2c5 = number of new class V requisitions received from destination 2, daily transaction

n2c7 = number of new class VII requisitions received from destination 2, daily transaction

n2c9 = number of new class IX requisitions received from destination 2, daily transaction

-S-

sump1a = sum of all pallets waiting for planeload configuration for destination 1, CONUS origin

sump1s = sum of all pallets waiting for shipload configuration for destination 1, CONUS origin

sump2a = sum of all pallets waiting for planeload configuration for destination 2, CONUS origin

sump2s = sum of all pallets waiting for shipload configuration for destination 2, CONUS origin

sump2o = sum of all pallets waiting for planeload configuration for destination 2, OCONUS origin

-U-

unfenc = percentage OCONUS inventories, above minimum stockages, to be made available on a given day

-X-

x = number of daily new acquisitions of class V items

-Y-

y = number of daily new acquisitions of class VII items

-Z-

z = number of daily new requisitions of class IX items

VITA

George C. Prueitt was born on 23 August 1955, at Fort Monmouth, New Jersey. He graduated from Henry County High School, New Castle, Kentucky, in May 1973. He received a Bachelor of Science degree in Mechanical Engineering, from the University of Kentucky in December 1977. He was commissioned in the Field Artillery, and initially assigned to Fort Sill, Oklahoma. Upon completion of the Field Artillery Officer Basic Course, he was assigned to the United States Army-Europe, in the Federal Republic of Germany. While in Germany, he commanded B Battery, 3d Battalion, 79th Field Artillery. Upon return from Germany, he completed the Infantry Officer Advanced Course, at Fort Benning, Georgia, and in August 1982, he was assigned to the School of Engineering, Air Force Institute of Technology.

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Robert L. Smith was born on 19 February 1953, in Niagara Falls, New York. He graduated from Widefield High School, Security, Colorado, in May 1971, and then attended the United States Military Academy. He was awarded a Bachelor of Science degree and was commissioned in the Infantry in June 1975. Following completion of the Infantry Officer Basic Course and Ranger School at Fort Benning, Georgia, he served with the 505th Infantry (Airborne) at Ft. Bragg, North Carolina. After completion of the Field Artillery Officer Advanced Course at Ft. Sill, Oklahoma, he was assigned to Korea as a Brigade S-3 and later as Aide-de-camp to the Commanding General of the 2d Infantry Division. Upon his return from Korea, he was assigned to Ft. Knox, Kentucky, where he served as Company Commander for A Company, 13th Battalion, 4th Brigade. Upon completion of his tour at Ft. Knox, he was assigned in August 1982 to the School of Engineering, Air Force Institute of Technology.

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Abstract

This thesis develops a basic methodology for modeling the effects of flexibility and responsiveness in U.S. Army contingency plan logistical support.

A model of the contingency logistical support environment was built using the SLAM computer simulation language. Four factors and their interactions were analyzed in the model. Those factors were priority system, other than CONUS supplies (OCONUS), diversion, and fencing (reserved stocks). The level of each factor was varied to determine its effect and interaction with the other factors. Both airlift and sealift were modeled.

The measure of effectiveness used was the number of pallets of critical items delivered per total time in the delivery system. The model provides a number of inputs which can be changed to determine parameter sensitivity. The model results, as expected, showed that contingency logistical support would be significantly upgraded if a revised priority system, OCONUS supply sites, and a diversion policy were used.